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Study of the Feasibility of a Regional Solid Waste Derived Fuel System in the Tennessee Valley Authority Service Area

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Tennessee Valley Authority
Chattanooga, Tennessee 37401
July 1976

STUDY OF THE FEASIBILITY OF A REGIONAL SOLID WASTE DERIVED FUEL SYSTEM IN THE TENNESSEE VALLEY AUTHORITY SERVICE AREA

Sponsored by
Environmental Protection Agency
Federal Energy Administration
Tennessee Valley Authority

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RESOURCE RECOVERY FROM MUNICIPAL SOLID WASTE - FEASIBILITY STUDY

By

Tennessee Valley Authority Personnel
B. G. McKinney - TVA Project Officer
Chattanooga, Tennessee 37401

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LEGAL NOTICE

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ABSTRACT

An evaluation of the feasibility of the economics of establishing a resource recovery system in the TVA region is presented. This system would consist of collecting, transporting and processing of the municipal solid waste and then using or selling the products from the process. Two basic alternatives are investigated for using the energy in municipal solid waste: (1) processing municipal solid waste and burning the fuel fraction with coal in a conventional TVA power boiler modified for that purpose and (2) converting municipal solid waste to a synthesis gas with subsequent conversion to fuel grade methanol for use in TVA's gas turbines modified to accept such a fuel. The study shows that with a dump fee of approximately $5.90 per ton of refuse paid by the producer of the refuse, 14,000 tons per week of solid waste, out of a total of 108,000 TPW produced in the TVA region can be collected, transported, processed, and the fuel fraction burned at the TVA steam plants considered in the economic evaluation in this report, but environmental standards will be violated. Also the study shows that with a dump fee of $11.00 per ton of refuse, 27,000 TPW of solid waste can be collected, processed to methanol, and burned in TVA's gas turbines without impacting generating costs of the TVA, or violating environmental standards.

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LIST OF ABBREVIATIONS

ACFM	Actual Cubic Feet Per Minute
Btu	British Thermal Unit
B&W	Babcock & Wilcox
CAP	Capacity
CE	Combustion Engineering
CFM	Cubic Feet Per Minute
CO	County
CONT	Continued
CU-YD	Cubic Yard
DC	Direct Current
DED	Division of Engineering Design
DISP	Dispatch
DPP	Division of Power Production
ECON	Economic
ESP	Electrostatic Precipitator
ETDD	East Tennessee Development District
F.D.	Forced Draft
FT	Foot
HCL	Hydrochloric Acid
HP	Horsepower
HR	Hour
HVAC	Heating, Ventilating, and Air Conditioning
I.D.	Induced Draft
IEA	Institute for Energy Analysis
LANDF	Landfill
LBS	Pounds
LHV	Lower Heating Value
MCR	Maximum Continuous Rating
MeOH	Methanol
MISC	Miscellaneous
Mg/l	Milligrams Per Liter
MRI	Midwest Research Institute
MSW	Municipal Solid Waste
MW	Megawatt
NCRR	National Center for Resource Recovery
NO	Number
NO_x	Oxides of Nitrogen
NPDES	National Pollutant Discharge Elimination System
OBW	Oversized Bulky Waste
OEDC	Office of Engineering Design
OHM-CM	OHM-Centimeter
O&M	Operation and Maintenance
OTAD	Office of Tributary Development
PPM	Parts Per Million
PSIG	Pounds Per Square Inch Gauge
REF.	Reference

LIST OF ABBREVIATIONS (CONT)

RPM	Revolutions per Minute
R.R.	Railroad
SCF	Standard Cubic Foot
SNG	Synthetic Natural Gas
SO_2	Sulfur Dioxide
SWDF	Solid Waste Derived Fuel
TPD	Tons Per Day
TPW	Tons Per Week
TPY	Tons Per Year
TVA	Tennessee Valley Authority
UE	Union Electric
VIP	Vibratory Impact Parts Separator
WK	Week
WLF	Waste Load Factor, Lbs Per Person - Day
YD	Yard
YD^3	Cubic Yard

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J. L. Wilbanks
W. W. Woods
H. S. Woodson
T. C. Worden

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J. C. Duggan
W. W. Filgo
J. R. Henson
J. T. Lawton
D. D. Luton
T. L. McDaniel
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J. A. Oppold
G. G. Park
D. M. Trayer

Division of Forrestry, Fisheries, and Wildlife

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K. L. Phang
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G. B. Tully

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J. G. Branam
C. Gottschalk
W. H. Thompson

Power Research Staff

C. K. Andrews
H. L. Falkenberry
B. G. McKinney
C. J. Powell

Division of Power Resource Planning

S. M. Bostick

Division of Purchasing

G. L. Jaynes
D. L. Owen
A. T. Scott

Division of Reservoir Properties

L. R. Beene

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SECTION I

EXECUTIVE SUMMARY

Study Purpose

For years the Tennessee Valley Authority has been conducting preliminary investigations of methods to dispose of municipal solid wastes in the Tennessee Valley region. Through these investigations and due to shortages of fuel supply, it became apparent that a more detailed investigation of the potential of resource recovery was appropriate. For approximately one year, TVA worked alone on a resource recovery project at a minimum level of effort. From this effort plans for a more extensive project evolved. Early in 1975, the Environmental Protection Agency, the Federal Energy Administration, and TVA entered into an agreement to study the feasibility of a resource recovery system. The results of that study are discussed in this report.

The purpose of the joint feasibility study was to determine technical, economic, and environmental issues associated with collecting, processing and selling salvaged materials, and burning the combustible fraction of municipal solid waste in conventional coal-fired boilers in the TVA system. An alternative was also studied involving the gasification of municipal solid waste and conversion to a fuel grade methanol for use in TVA's gas turbines. The estimates for the processing plants and power plant modifications concerned with producing and burning the combustible fraction in coal-fired boilers were prepared by TVA in accordance with Federal Power Commission practices. Cost estimates associated with gasification concepts were prepared by the Institute for Energy Analysis, a Division of Oak Ridge Associated Universities. The format of the estimates prepared by IEA was revised so that they could be compared on the same basis as other estimates in this study.

Some of the main findings of the study are:

1. Cost estimates and revenue estimates are not transferable to another study area; the former because of differences in waste quantities, transportation costs, variations in the cost of facilities to process and utilize the fuel, and differences in construction costs; the latter because of differences in waste characteristics from place to place, the availability of suitable markets, and on the value of fuel to different users. However, the methods used to determine these estimates are transferable.

2. Collection and transportation costs are a major cost element in any regional resource recovery system operating in a region with dispersed population and with power plants remotely located from urban areas. Approximately 1/5 to 1/3 of the cost of the alternatives considered in the TVA study can be attributed to transportation. If significant quantities of waste must be transported more than 50 miles to a processing center, rail haul should be considered. The most economical method of rail hauling is a rotary-discharge hopper car. Storage requirements in the system should take advantage of storage available in transportation systems.

3. The optimum waste supply would be in the range of 2,000 to 3,000 tons per day.

4. Screening of raw waste prior to shredding by using a rotating trommel can produce processing benefits, including extraction of most glass and a majority of the metal cans.

5. Glass and aluminum recovery should be considered on an add-on basis.

6. The newest electrostatic precipitators (ESP) either installed, under construction, or planned at the TVA fossil-fired steam plants considered in this study, when performing at their design efficiency, may control emissions sufficiently at some plants to prevent violations of particulate emission standards when the boiler is fired with a 10 percent Btu input from solid waste derived fuel (SWDF). However, it has been reported that ESP efficiency decreases 1 to 3 percent when burning coal combined with SWDF; and therefore, violations of these standards may occur at all these plants. Actual validation of the adequacy of the ESP's performance in meeting emission standards when burning coal combined with SWDF will be required even though ESP's at some plants will have a safety margin that might handle increases in particulate inlet loading. Ambient particulate standards are not expected to be exceeded when point source particulate emission standards are met.

7. Ground and surface waters at and near the steam plants are not expected to be adversely affected by firing with SWDF when a quality fuel sized for maximum possible combustion and essentially free of noncombustible material is provided.

8. There is not sufficient information available regarding the use of SWDF in large power boilers to conclude its effects on boiler corrosion, electrostatic precipitator performance, bottom ash and ash pond contamination, and boiler efficiency. These and other technical questions, such as SWDF firing rates and boiler loads at which these rates can be used, need to be answered.

9. Syngas from solid waste and products synthesized from that syngas are expensive in terms of today's prices and have not yet been produced on a commercial scale. Methanol and ammonia produced as a result of coal gasification should be considerably cheaper than the fuel produced from municipal solid waste, although the capital required is considerably greater.

Study Conclusions

The development of this regional resource recovery system for a part of the Tennessee Valley region must consider both economic and environmental factors. This system could be developed without adversely affecting electric power rates if adequate payments from other sources could be obtained and acceptable contingency provisions included for payments if costs exceeded expected levels, but it would also require validation that environmental standards would not be violated. Payments to assure that electric rates would not be adversely affected could range from $7 to $17 for each of approximately 14,000 tons of refuse processed per week into fuel for a coal-fired boiler.* To obtain the minimum condition of $7 per ton, it would be necessary to operate the processing plant two shifts, seven days per week. This may not allow sufficient time to perform all required maintenance functions on a continuing basis. If waste were to be gasified and converted to a methanol fuel for TVA gas turbines, the estimated payments could range from $11 to $17 for each of approximately 27,000 tons of waste processed each week. In both cases the level of payments would depend to a large extent on the financing period, with 10-year financing--demanding the higher payments and 20-year financing requiring the lower. Also it can be easily shown that interest rates would effect the payment level as illustrated in this study, but the impact of interest rates are not as great as other factors. (See figures 14-13 and 14-14)

The technology appears to be available for producing either a solid, gaseous, or liquid fuel from solid waste. Tests need to be conducted to determine the effects of burning such fuels in components of the TVA system. Such tests should be a part of any development program aimed at implementing specific resource recovery concepts.

---

*An interest rate of $8\frac{1}{2}$ percent was assumed for this analysis. If a 7 percent annual rate were appropriate, the minimum payment required drops to $5.90. (See figure 14-13.)

SECTION II

SUMMARY

The cooperative Environmental Protection Agency, Federal Energy Administration, and Tennessee Valley Authority feasibility study conducted by TVA was divided into several tasks and were performed by various TVA organizations and contractors. The specific areas studied are discussed in the following summaries of these tasks.

Solid Waste Supply and Availability

Approximately 22,000 tons of solid waste materials are generated daily by the 6.7 million people residing in the TVA power service area. Of this amount, only about 49 percent is presently being collected; the remaining waste is being burned or dumped at random locations. A county-by-county survey was conducted by OTAD to determine the quantities of solid waste being collected in the region and to assess the availability of such quantities. Information on solid waste collection and disposal systems was obtained through the cooperation of state and local solid waste officials and from regional planning and development districts. Based on this information, a procedure was developed and used by OTAD for estimating waste quantities for each of the 201 counties in the power service area. The reliability of the waste estimates was confirmed by a 16-county survey conducted by the East Tennessee Development District.

Cost studies indicated that the counties collecting less than 30 tons per day would not realize significant cost savings by participating in a regional resource recovery system. The total waste quantity expected from the counties with over 30 tons per day amounts to over 45,000 tons per week which can be considered as an available solid waste supply for the regional system. These solid waste supplies are concentrated in nine locations in the TVA power service area and are listed below.

Eastern Region	Tons Per Week
Asheville, NC	2,100
Tri Cities, TN	4,100
Knoxville, TN	7,500
Chattanooga, TN	5,500
Subtotal	19,200

Western Region	Tons Per Week
Huntsville, AL	9,400
Nashville, TN	12,200
Paducah, KY	1,100
Jackson, TN	1,400
Tupelo, MS	2,300
Subtotal	26,400
Total	45,600

Revenues from the sale of materials recovered from the region's waste stream are to be used to offset project costs. To establish a level of confidence in revenue potential the quantity of marketable items in the waste stream had to be determined. To accomplish this, a sampling program was initiated. A mobile unit traveled throughout the region sampling wastes at major landfills. To determine the extent of seasonal variations, three sampling periods were used: Summer of 1974, Spring of 1975, and Summer of 1975.

	Composition by Weight			
	National Average	TVA Summer 74	TVA Spring 75	TVA Summer 75
Combustibles & inert materials	85%	62.3%	73%	73%
Ferrous metals	7%	13.0%	11%	11%
Mixed glass	7%	22.0%	15%	15%
Mixed nonferrous metals	1%	2.7%	1%	1%

During this study an analysis was made to determine what effect "Mandatory Deposit" legislation might have on future revenue trends. Beverage cans constitute approximately 22% to 26% by weight of the ferrous metals and 28% to 32% of the nonferrous metals. This means that if such legislation is enacted, 25% of the metals revenue could be lost.

To test the credibility of sampling results, the University of Tennessee's Environment Center was contracted to perform a statistical analysis on data obtained. Their studies indicate that the procedure used for sampling was adequate and consistent. Basically the center concluded that there will always be a subjective element in any solid waste sampling data obtained. The reason being that components of the waste stream vary widely with time and only through extended sampling can this variation be detected. Consequently, continued monitoring of the region's waste stream is recommended if a system to produce SWDF is implemented.

Transportation, Site Location of Processing Plants, Storage, and Handling

The selection of processing plant locations was dependent on which power plants were to be selected to burn the fuel product. Bull Run and Cumberland Steam Plants were selected as the most satisfactory plants to receive the processed fuel fractions. Kingston Steam Plant is a possible alternate for Bull Run. At 100% of MCR, the following

SWDF Burn Rates would supply 10% of the BTU input:

Cumberland	(1 unit)	2,300 TPD
	(2 units)	4,600 TPD
Bull Run		1,600 TPD
Kingston	(4 units)	1,500 TPD
	(5 units)	1,900 TPD

Cumberland Steam Plant, which could serve the western portion of the region, would be capable of burning the fuel fraction derived from approximately 30,000 tons of solid waste per week. Nashville, Tennessee; Jackson, Tennessee; Paducah, Kentucky; Tupelo, Mississippi; and Huntsville, Alabama could provide 26,400 tons per week to be processed for the Cumberland power plant. Bull Run, at a burn rate of 1,500 tons per day, would be capable of burning the fuel fraction from 14,000 tons of solid waste per week.

Approximately 19,000 tons of waste per week from the major concentration points in the eastern half of the power service area (see Figure 2-1) are potentially available from Asheville, North Carolina; Tri-Cities, Tennessee; Chattanooga, Tennessee; and Knoxville, Tennessee. The 5,000 tons per week excess (2.700 tons of fuel) was assumed to be consumed by a paper fiber recovery industry.

Transportation and marketing studies indicated a single processing plant located in each of the two regions could serve the nine major waste concentration points. Each plant should be located in the largest metropolitan complex nearest the power plant to be used, i.e., Nashville and Knoxville. Regional transfer stations at the major waste concentration points allow shipment of the waste to these control processing plants. Exhibit A shows an optimum location for the two processing plants and the regional transfer stations.

The transportation network for a regional resource recovery system would consist of three basic elements: (1) the transfer of waste from locally-owned transfer stations to TVA-owned and -operated regional transfer stations; (2) long distance transport of waste from the regional transfer stations to the processing plants; and (3) the transport of the fuel fraction from the processing plants to the steam plants.

Transporting solid waste from regional transfer stations to the processing plants should be by rail. Rail haul networks are based on TVA owning and maintaining the rail cars with the railroad companies furnishing the locomotives and crews. Southern Railway serves the eastern part of the region and L&N Railroad serves the western region.

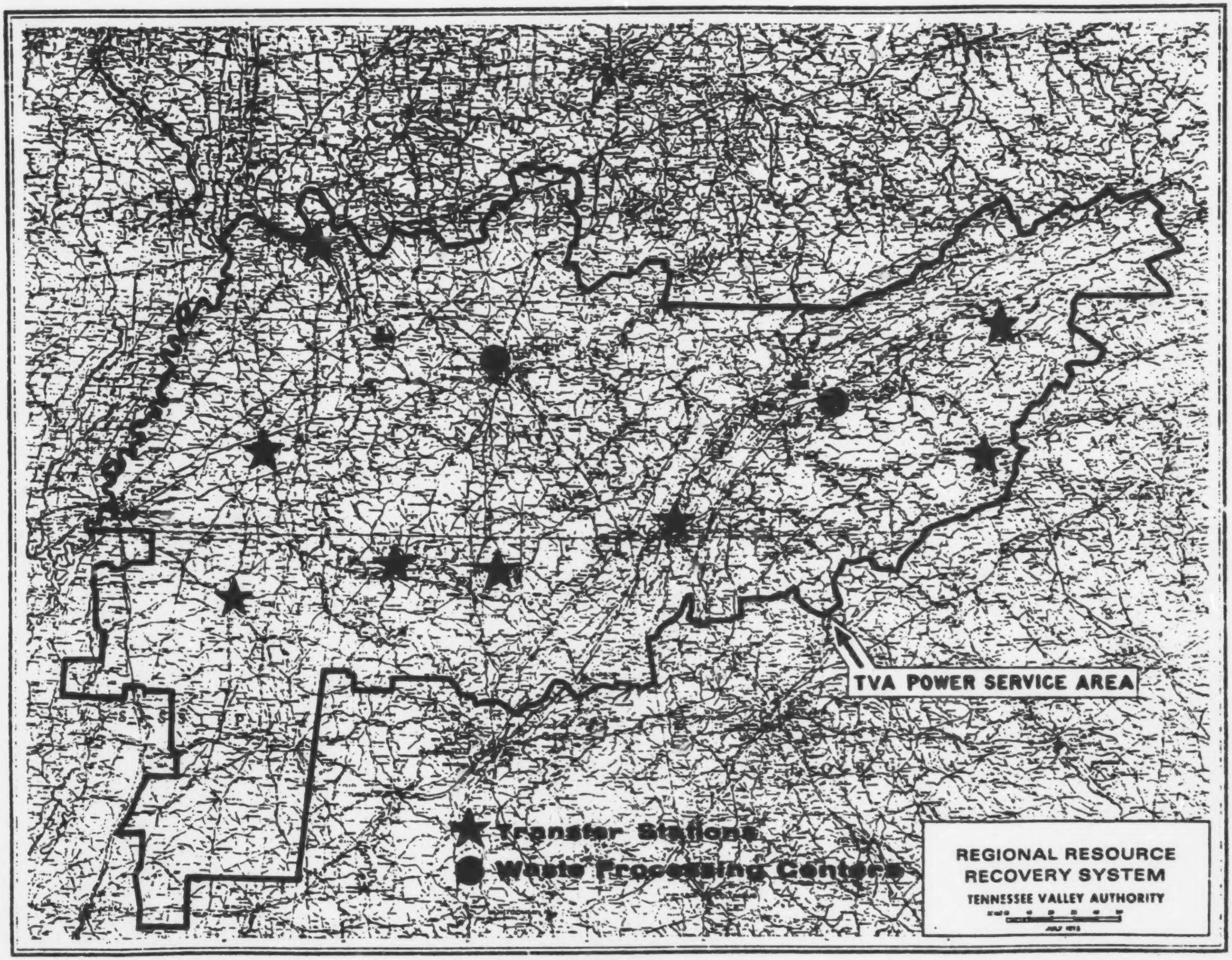
TVA POWER SERVICE AREA
Transfer Stations
Waste Processing Centers
REGIONAL RESOURCE
RECOVERY SYSTEM
TENNESSEE VALLEY AUTHORITY

FIGURE 2-1

Four types of rail haul systems were investigated. The rotary discharge, uncompacted hopper car was judged to be the most economical approach. This type of car is illustrated in Figure 2-2.

Delivery of the fuel fraction to the steam plants could be by over-the-road equipment or by rail using the same systems described above. Fuel from the Knoxville processing plant would be transported by truck to Bull Run or by rail if Kingston were utilized. Cumberland Steam Plant should receive the fuel fraction by rail. Cost estimates for the modification of each plant considered includes facilities for receiving SWDF shipped by truck and rail.

Tables 2-1 and 2-2 summarize the transportation costs for the two regions. The total transportation cost estimates for the Nashville-Cumberland and Knoxville-Bull Run regions were $6.90 per ton and $5.60 per ton, respectively.

Processing Plant - Design and Cost Estimate

The proposed municipal solid waste processing facility would be capable of processing 2,000 tons of raw refuse per day (two eight-hour shifts). The output from this tonnage consists of the fuel product (54.4%), massive ferrous (3.6%), crude ferrous product (6.4%), crude nonferrous product (13.8%), and the crude glass product (21.8%). Additional processing is necessary to obtain useable products from the three crude products.

The processing facility consists of a large receiving pit where waste is received by both truck and rail carriers and a processing area containing two identical, but completely independent, process lines. Each line has processing equipment which, in sequential operations, tumbles, breaks, shreds, screens, and segregates the incoming wastes into the desired major constituents. All units in the processing lines are totally integrated by conveyors--mechanical and pneumatic--to provide an automatically controlled, continuous processing system from raw refuse input to usable or salable products at the output. Shipment of all output products is by truck or railhaul carriers.

The capital cost for such a facility, including construction, materials, labor, major equipment, conveyors, building, foundation, and site (land, railroads, roads, etc.), is estimated by TVA to be $35,000,000; the estimate provided by Black, Crow, and Eidsness is $33,850,000.* Both cost estimates are based on 1977 dollars with an accuracy of ± 30 percent.

Product Marketing

A basic premise of the regional resource recovery system study is that revenues from recoverable products plus a dump fee must offset project costs. Marketable recoverable products from which revenue may be derived are:

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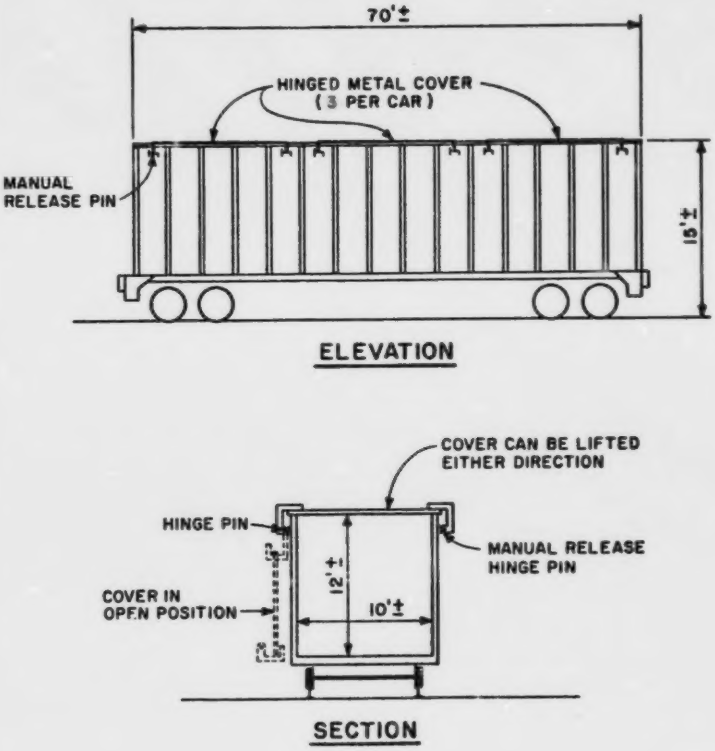
*These prices will change due to increase for railroad car dumper.

Figure 2-2


70'±
HINGED METAL COVER
(3 PER CAR)
MANUAL
RELEASE PIN
15'±
ELEVATION
COVER CAN BE LIFTED
EITHER DIRECTION
HINGE PIN
MANUAL RELEASE
HINGE PIN
12'±
COVER IN
OPEN POSITION
10'±
SECTION

CAPACITY - 8000 CU. FT. ±
PAYLOAD - 40 TO 50 TONS
LOOSE REFUSE DENSITY - 300 TO 350 LBS PER C.Y.

ROTARY DISCHARGE HOPPER CAR

REGIONAL RESOURCE
RECOVERY SYSTEM

TENNESSEE VALLEY AUTHORITY
1975

TABLE 2-1

AVERAGE ANNUAL TRANSPORTATION COST SUMMARY - NASHVILLE WASTE SERVICE REGION

Stage II: Probable Coverage for Fully Developed System

Service Area	Waste Quantity tons/wk	Service Area Transportation Costs	Regional Truck-to-Rail Transfer Station	Transportation Costs to Processing Plant	Dispatch and Cleaning Services	Transportation of Fuel to Steam Plant
Paducah, KY	1,100	$ 123,000	$ 130,000	$ 315,000		
Jackson, TN	1,400	172,000	254,000	393,000		
Tupelo, MS	2,300	401,000	254,000	698,000	$199,000	$961,000 (13,200 TPW)
Huntsville, AL	9,400	1,520,000	391,000	2,415,000		
Nashville, TN	12,200	1,220,000				
(Subtotals)	26,400	$3,436,000	$1,029,000	$3,821,000	$199,000	$961,000

Total Average Annual Cost: $9,450,000

($6.90/ton)

TABLE 2-2

AVERAGE ANNUAL TRANSPORTATION COST SUMMARY - KNOXVILLE WASTE SERVICE REGION

Stage II: Probable Coverage for Fully Developed System

Service Area	Waste Quantity tons/wk	Service Area Transportation Costs	Regional Truck-to-Rail Transfer Station	Transportation Costs to Processing Plant	Dispatch and Cleaning Services	Transportation of Fuel to Steam Plant	Total Average Annual Cost
Asheville, NC	2,100	$ 68,700	$254,000	$ 411,000		Kingston S.P. $748,000	Kingston S.P. Option $5,630,000 ($5.65/ton)
Chattanooga, TN	5,500	297,000	391,000	871,000			
Tri Cities, TN	4,100	553,000	309,000	882,000	$199,000	Bull Run S.P. $681,000	Bull Run S.P. $5,570,000 ($5.60/ton)
Knoxville, TN	7,500	648,000	———	———	———		
(Subtotals)	19,200	$1,566,700	$954,000	$2,164,000	$199,000		

1. Fuel product
2. Ferrous metals
3. Nonferrous metals
4. Mixed-color glass

The fuel product would be utilized by TVA. The remaining metal and glass products could be sold to industry. An invitation to bid on the recoverable metals and glass products was developed and issued for industry consideration. Industry bids were opened on September 3, 1975. Based on bid data, revenue potential for a 14,000-ton-per-week processing plant in Knoxville that would deliver fuel product to the Bull Run power plant was determined as follows:

> Fuel--The fuel product was assumed to be 54 percent of incoming raw refuse with a heating value of 6,000 Btu's per pound. The gross value of the fuel product at Bull Run was set at $0.73 per million Btu's of energy. This value translates to a revenue potential of $3.80 per ton of waste processed. Only about 80% of the solid waste derived fuel delivered to the Bull Run Steam Plant could be burned as there is only one unit at this location. The revenue potential would be approximately $4.75 per ton of waste processed if 100% of the solid waste derived fuel could be used.
>
> Ferrous Metals--The ferrous metals were assumed to be purchased by a detinning company at a price that translates to approximately $4.50 per ton of incoming waste. The detinning company would locate its processing plant adjacent to TVA waste processing facility.
>
> Aluminum--Aluminum can be marketed for approximately $400 per ton which translates to a revenue of $4.40 per ton of waste processed.
>
> Nonferrous Metals (excluding aluminum)--Useful bid information on this product was not received due to the lack of a good bid mechanism. However, industry is willing to purchase this material on a spot-sale basis. A conservative value assigned to this product would be $200 per ton, which translates to approximately 50¢ per ton of waste processed.
>
> Froth-floated mixed-color glass--Letters of intent to purchase varying quantities of the glass product have been received from at least five companies. The glass product could be sold at $15 to $20 per ton f.o.b. glass purchasers place of business. It costs $5 to $8 per ton to produce the glass and another $5 per ton to transport it to the glass user. The net revenue per ton of glass would be $5 to $10. This translates to approximately 50¢ per ton of waste processed. The total revenue potential is summarized as follows.

Product	Potential Revenue Per Ton of Waste Processed
Fuel	$ 3.80
Ferrous metals	4.50
Aluminum	4.50
Nonferrous metals excluding aluminum	.50
Froth-floated glass	.50
	$13.70

Power Plant Modifications

The Division of Engineering Design has estimated the cost to modify Kingston units 5-9, Cumberland units 1 and 2, Colbert units 1-4, and Bull Run. The estimated costs include a complete system to receive SWDF by truck or rail and unload it into a receiving building to be pneumatically conveyed to four silos and stored. It is then conveyed by air from positive displacement blowers located in the blower building and blown through process piping to the boilers which have been modified to burn the SWDF. All plant site receiving, unloading, transport, and storage equipment and equipment facilities required to burn SWDF are included.

The capital cost estimated for the modifications at the power plants are influenced by a design criteria which emphasizes minimizing labor and/or operating costs. Another factor which influenced the capital cost estimates is that processing plant and power plant are separated by approximately 25 miles.

The estimated cost of modification for these plants are itemized in Table 2-3. The costs shown are in 1977 dollars, and the total estimate for each plant is within an accuracy of ± 30% based on similar previous similar cost information.

Economic Analysis of Solid Waste Derived Fuel Used As A Supplemental Coal-Fired Boiler

The major item of expense was the estimated investment required at the power plants for refuse receiving and storage facilities, SWDF handling and transport piping, and boiler modifications, which were designed to handle an amount of SWDF equivalent to 20 percent of the Btu input required for the unit at its maximum critical rating.

The capital costs/kW ranged from approximately $14/kW for a 2,600-MW plant to $34/kW for a 846.5-MW plant. On the basis of investment required for each ton of SWDF burned in one day, the estimates ranged from $17,000/ton for one 950-MW plant to $20,000/ton for a 1,000-MW plant with 5 units. In addition, Table 10-2 has been provided to show annual cost in dollars per ton of MSW converted to SWDF used at the plant.

TABLE 2-3

Estimate of Power Plant Modification Cost

	THOUSANDS OF DOLLARS			
	Kingston 5-9	Cumberland 1-2	Colbert 1-4	Bull Run 1
Yard Work	$ 300	$ 1,000	$ 1,800	$ 500
Structures	1,230	1,280	1,030	1,040
Furnace Entry Modifications	295	390	200	120
Powerhouse Modifications	55	60	50	40
Process Equipment	5,600	7,600	4,400	4,100
Storage Silo	4,000	5,000	4,300	4,300
Miscellaneous Equipment	700	700	700	700
Electrical Work	2,800	2,270	1,750	1,750
Subtotal	14,980	18,300	14,230	12,550
Construction Facilities	1,500	1,830	1,420	1,260
Total Direct Construction	16,480	20,130	15,650	13,810
Field General Expenses	1,650	2,010	1,570	1,380
Contingency	3,430	4,115	3,480	2,695
Total Field Construction	21,560	26,255	20,700	17,885
Engineering Design	1,200	1,150	1,125	1,125
Manager's Office - OEDC	70	85	65	60
CSB - Engineering Group	20	20	20	20
Personnel	30	30	30	30
Purchasing	120	120	120	120
Medical Services	60	60	60	60
Employee Compensation Benefits	300	300	300	300
A&G	240	280	230	200
Interest During Construction	1,400	1,700	1,350	1,200
Total Project (1975 Dollars)	$25,000	$30,000	$24,000	$21,000
Escalated to 1977 Dollars	$30,000	$36,000	$29,000	$25,550

Note: Estimates are for 2000 ton storage at the plant , and the system is capable of furnishing RDF to the boiler at a rate of 20% of the input Btu's.

Other expenses expected to increase due to burning SWDF were: (1) operating and maintenance, (2) ash disposal, and (3) increased heat input to the boiler due to decrease in boiler efficiency. The commitment to burn refuse at a power plant may require units with high incremental costs to be kept in operation when the economic dispatch system would assign generation to lower cost units. The economic dispatch penalty due to refuse burning was estimated on an annual basis and these costs were used in our evaluation of the proposal to burn solid waste derived fuel.

The gross value of SWDF is based upon the value of the coal it would replace. This value ranged from $3.80 to $5.90 per ton of MSW processed at four separate TVA plants (see Table 10-8). These values were based on 1975 coal costs ranging from $14 to $18 per ton at these plants, a higher heating value of 11,000 Btu per pound.

Technical Problems Associated with Burning Solid Waste Derived Fuel in a Coal-Fired Boiler

Based on literature searches and consulting with Union Electric Company, TVA concludes that it is premature to commit more than two of its boilers to supplemental refuse firing until certain technical problems can be fully evaluated. There is considerable experience in refuse firing in stokers and incinerators, but to date, Union Electric is the only organization in the United States firing refuse in suspension with pulverized coal. Union Electric's work is encouraging; however, they and others warn that extrapolation of their results to other units is dangerous because of differences in boiler design, coal, and refuse. We feel that potential technical and operating problems (especially corrosion, precipitator performance, and bottom ash fallout) must be characterized at a TVA plant to assure that plant availability and consumer power rates will not be adversely affected.

Waste Gasification As An Alternative to Solid Fuel Processing

The Institute for Energy Analysis (IEA), a division of the Oak Ridge Associated Universities, was retained by TVA to investigate the feasibility of gasification as an alternative to the processing of a solid fuel.

Ammonia and methanol synthesis are two alternatives which were selected and discussed at length in IEA's report, "Gasification of Solid Waste - An Alternative to Solid Fuel." A number of other alternatives were considered, but rejected. These are also included in IEA's report.

The report concludes by recommending the development of a program for a TVA coal/oil/natural gas strategy, consideration of Watts Bar as a potential site for a MeOH from MSW processing plant and consideration of MeOH and ammonia synthesis in any planned TVA coal gasification strategy. The following are three conclusions made from this study:

1. Both fuel oil and natural gas are in short supply. The syngas produced from solid waste could become a substitute for oil (in the case of methanol) and for natural gas (in the case of ammonia production).

2. TVA may be able to consume, through its power production and fertilizer manufacturing activities, either, or both, MeOH and ammonia which would eliminate the need for any external sales of these products.

3. Syngas from solid waste and products synthesized from that syngas are expensive in terms of today's prices and have not yet been produced on a commercial scale. Methanol and ammonia produced as a result of coal gasification should be considerably cheaper than the fuel produced from municipal solid waste, although the capital required is considerably greater.

Environmental Assessment

Preliminary environmental evaluations indicate no insuperable problems in providing protection to employee health, safety, and welfare and to the environment. Routine monitoring of the work environment, as well as routine medical observation of employees, will be required.

The newest electrostatic precipitators (ESP) either installed, under construction, or planned at the TVA fossil-fired steam plants considered in this study, when performing at their design efficiency, may control emissions sufficiently at some plants to prevent violations of particulate emission standards when the boiler is fired with a 10 percent Btu input from solid waste derived fuel (SWDF). However, it has been reported that ESP efficiency decreases 1 to 3 percent when burning coal combined with SWDF; and therefore, violations of these standards may occur at all these plants. Actual validation of the adequacy of the ESP's performance in meeting emission standards when burning coal combined with SWDF will be required even though ESP's at some plants would have a safety margin that might handle increases in particulate inlet loading and increases in gas flow. Ambient particulate standards are not expected to be exceeded when point source particulate emission standards are met.

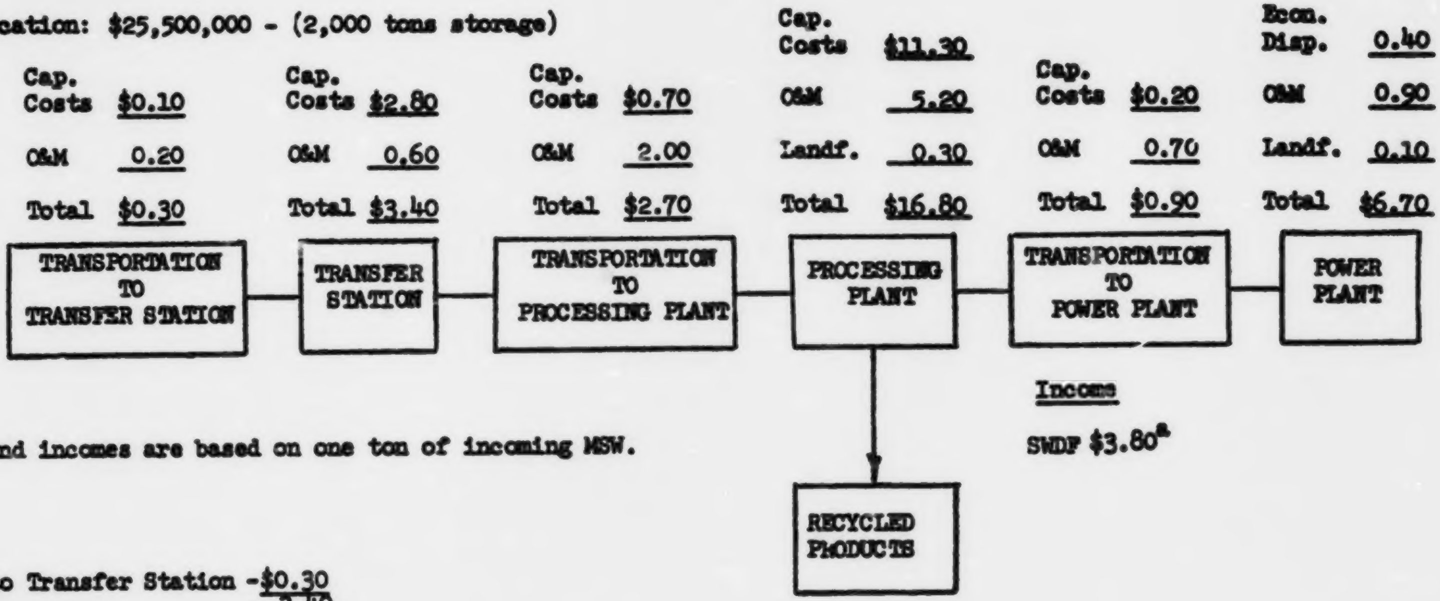
Findings of Study

To summarize the economics of a resource recovery system, several figures were prepared using data from this feasibility study. As indicated on Figures 2-3 and 2-4 when producing a solid waste derived fuel to be used as a supplemental fuel at the TVA's Bull Run Steam Plant, a dump fee of From $7 to $17 per ton of processed refuse would be charged to avoid an impact on electric rates. If the interest rate were changed from 8-1/2 down to 7 percent, these

FIGURE 2-3

Time Period : 10 years
Process Plant Cost : $54,000,000 - (2,800 TPD, 5 days/week - 14,000 TPW - 728,000 TPY)

Power Plant Modification: $25,500,000 - (2,000 tons storage)


Cap. Costs $0.10
O&M 0.20
Total $0.30
TRANSPORTATION TO TRANSFER STATION
Cap. Costs $2.80
O&M 0.60
Total $3.40
TRANSFER STATION
Cap. Costs $0.70
O&M 2.00
Total $2.70
TRANSPORTATION TO PROCESSING PLANT
Cap. Costs $11.30
O&M 5.20
Landf. 0.30
Total $16.80
PROCESSING PLANT
Cap. Costs $0.20
O&M 0.70
Total $0.90
TRANSPORTATION TO POWER PLANT
Cap. Costs $5.30
Econ. Disp. 0.40
O&M 0.90
Landf. 0.10
Total $6.70
POWER PLANT
Income
SWDF $3.80[a]
RECYCLED PRODUCTS

NOTE: All costs and incomes are based on one ton of incoming MSW.

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

Costs

Transportation to Transfer Station	-$0.30	
Transfer Station	- 3.40	
Transportation to Processing Plant	- 2.70	
Processing Plant	-16.80	
Transportation to Power Plant	- 0.90	
Power Plant	- 6.70	
Total Costs		-$30.80

Income

Sale of Recycled Products	$9.90	
Sale of SWDF	3.80[a]	
		$13.70
NET		-$17.10

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

[b] Assumes that aluminum and glass products can be produced to meet specifications.

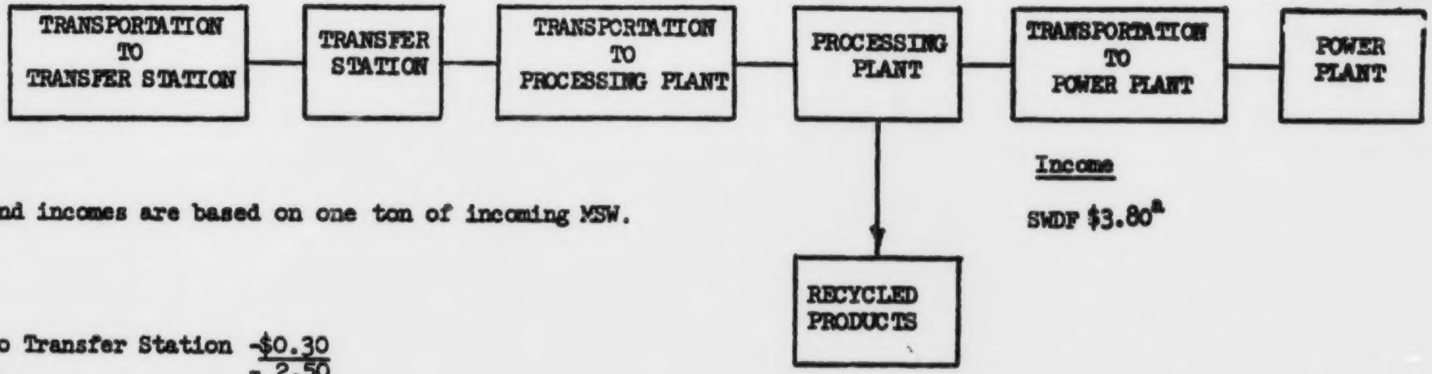
FIGURE 2-4

Time Period : 20 years
Process Plant Cost : A $35,000,000
B $36,000,000
C $38,000,000

(2,000 TPD, 7 days/week - 14,000 TPW - 728,000 TPY)

Power Plant Modification:

	Transportation to Transfer Station	Transfer Station	Transportation to Processing Plant	Processing Plant	Transportation to Power Plant	Power Plant
Cap. Costs	$0.10	$1.90	$0.70	A $ 5.10	$0.20	$2.00
Econ. Disp.						0.50
O&M	0.20	0.60	2.00	5.20	0.70	1.10
Landf.				0.30		0.10
Total	$0.30	$2.50	2.70	A $10.60	$0.90	$3.70


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.80[a]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

Costs

Transportation to Transfer Station	-$0.30
Transfer Station	- 2.50
Transportation to Processing Plant	- 2.70
Processing Plant	-10.60
Transportation to Power Plant	- 0.90
Power Plant	- 3.70
Total Costs	A -$20.70

Income

Sale of Recycled Products	$9.90
Sale of SWDF	3.80[a]
	$13.70

	A	B	C
NET	-$ 7.00	-$7.10	-$7.40

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

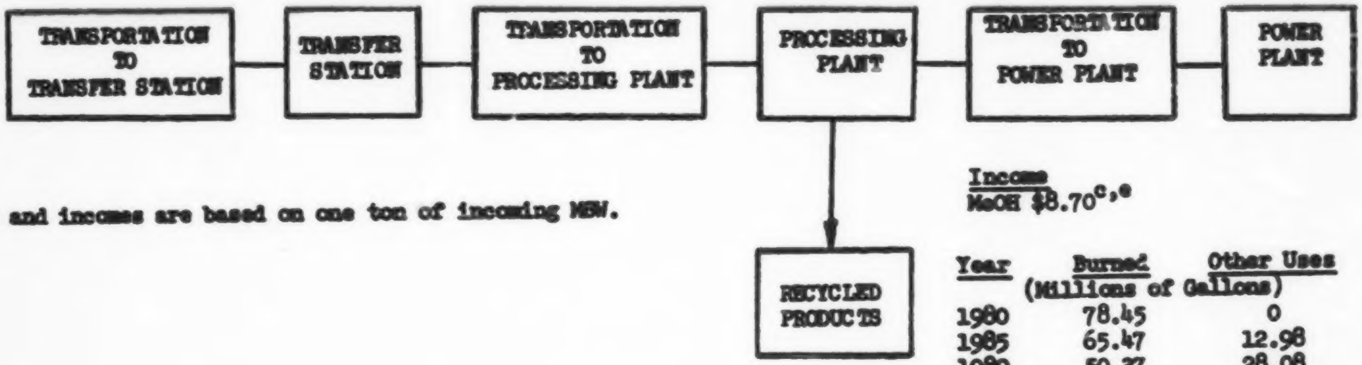
[b] Assumes that aluminum and glass products can be produced to meet specifications.

FIGURE 2-5

Time Period : 10 years
Processing Plant Cost: $56,000,000 (3,850 TPD, 7 days/week - 27,000 TPW - 1,404,000 TPY)

Gasification & Methanation Plant Cost Including Pumping Station To Methanation Plant = $105,000,000

Cap. Costs	$0.60	Cap. Costs	$2.60	Cap. Costs	$1.10	Cap. Costs	$17.50	Cap. Costs	$0.10	Cap. Costs	$1.10[b]
										Econ. Disp.	
O&M	1.00	O&M	0.50	O&M	2.40	O&M	8.90	O&M	0.30	O&M	
						Landf.				Landf.	
Total	$1.60[d]	Total	$3.10[d]	Total	$3.50[d]	Total	$26.40[a]	Total	$0.40	Total	$1.10[b]


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income
MeOH $8.70[c,e]

Year	Burned	Other Uses
	(Millions of Gallons)	
1980	78.45	0
1985	65.47	12.98
1989	50.37	28.08

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation	-$ 8.20	
Processing Plant	- 26.40	
Transportation to Power Plant	- 0.40	
Power Plant	- 1.10	
Total Costs		-$36.10

Income

Ferrous	$4.50
Glass & Metals	1.00[f]
Aluminum	4.40[f]

Income

Sale of Recycled Products	$ 9.90	
Sale of SWDF	8.70	
Total Income		$18.60
NET		-$17.50

Notes:

[a] Includes $0.50/ton O&M and $1.20/ton capital charges for preprocessing MSW.

[b] Includes cost of modifying gas-turbines & fuel storage facilities

[c] Based on projected average cost of No. 2 oil in 1977.

[d] MSW transportation costs estimated by scaling up solid fuel transportation costs.

[e] Assumes all methanol produced can be used in TVA turbines.

[f] Assumes that aluminum and glass products can be produced to specification.

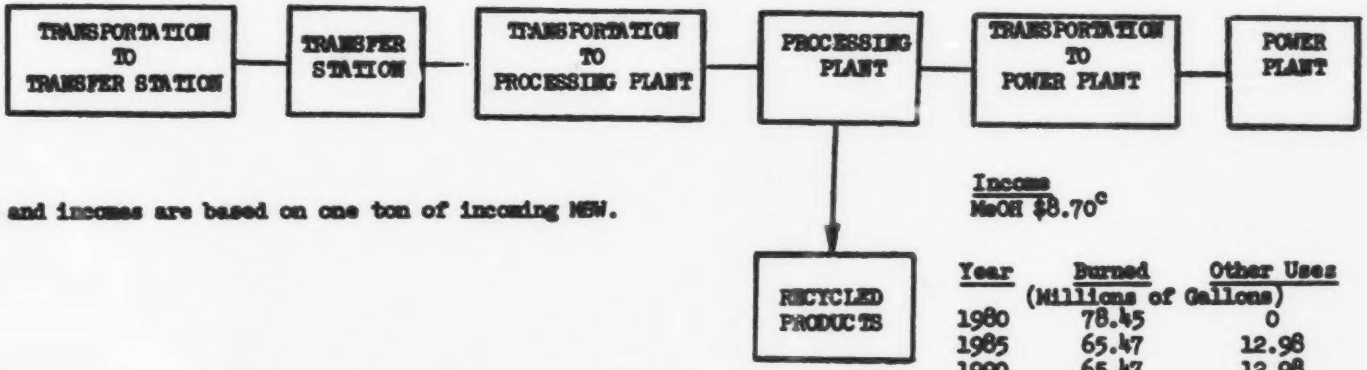
1-30-76

FIGURE 2-6

Time Period : 20 years
Processing Plant Cost: $56,000,000 (3,850 TPD, 7 days/week - 27,000 TPW - 1,404,000 TPY)

Gasification & Methanation Plant Cost Including Pumping Station To Methanation Plant = $105,000,000

	Transportation to Transfer Station	Transfer Station	Transportation to Processing Plant	Processing Plant	Transportation to Power Plant	Power Plant
Cap. Costs	$0.60	$1.80	$1.10	$12.10	$0.10	$0.80[b]
Econ. Disp.						____
O&M	1.00	0.50	2.40	____	0.30	____
Landf.				8.90		____
Total	$1.60[d]	$2.30[d]	$3.50[d]	$21.00	$0.40	$0.80[b]



TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income
MeOH $8.70[c]

Year	Burned	Other Uses
	(Millions of Gallons)	
1980	78.45	0
1985	65.47	12.98
1990	65.47	12.98
1995	55.44	23.01
1999	30.26	48.20

Income

Ferrous	$4.50
Glass & Metals	1.00[f]
Aluminum	4.40[f]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation	-$ 7.40	
Processing Plant	- 21.00	
Transportation to Power Plant	- 0.40	
Power Plant	- 0.80	
Total Costs		-$29.60

Income

Sale of Recycled Products	$ 9.90	
Sale of SWDF	8.70	
Total Income		$18.60
NET		-$11.00

Notes:

[a] Includes $0.50/ton O&M and $1.20/ton capital charges for preprocessing MSW.
[b] Includes cost of modifying gas-turbines & fuel storage facilitie
[c] Based on projected average cost of No. 2 oil in 1977.
[d] MSW transportation costs estimated by scaling up solid fuel transportation costs.
[e] Assumes all methanol produced can be used in TVA turbines.
[f] Assumes that aluminum and glass products can be produced to specification

values would be reduced to $5.90 and $9.90 for periods of 10 and 20 years, respectively (See Figure 14-13). Also, from these two figures, it can be concluded that for the TVA, it is not profitable in any case to use the fuel, since the cost of using it is greater than the value of the fuel ($4.20 versus $3.80). Figures 2-5 and 2-6 similarly indicate that the production of methanol from refuse may not be economically viable. However, before concluding that it is not economically viable to produce methanol from refuse, a more detailed cost and marketing study should be performed. It should be pointed out that although the costs in Tables 2-2 and 2-6 may appear higher than projected costs for other systems, they reflect conservative engineering design criteria with emphasis on minimizing labor cost and maximizing operability as well as meeting required inplant environmental standards. A comparison of costs based on 8-1/2 and 7 percent financing is shown in Figure 14-14. Also, location of the processing plant 25 miles from the power plant results in higher transportation and handling costs.

SECTION III

INTRODUCTION AND BACKGROUND

Following a substantial preliminary investigation, it became apparent that there was a need for a design and economic research study program to consider establishment of a system for energy and resource recovery from municipal solid waste in the Tennessee Valley region. Such a study has been made, and the results are compiled in this report. The regional resource recovery system studied, and reported herein, incorporates the salvage of the reusable fractions of municipal solid waste (MSW) for resale and provides for burning the combustible fraction in steam-electric boilers or, as an alternate, processing it for use in gas turbines. The feasibility for such a system is enhanced by the fact that traditional energy resources are in scarce or limited supply and increasing in cost not only in the Tennessee Valley region but throughout the world. Projects of this sort could (a) result in the development of a new energy resource, (b) save for TVA the energy equivalent of one million tons or more of coal per year through substitution of solid waste derived fuel (SWDF), and (c) save energy in the industrial sector because recycling of aluminum, steel, glass, etc., is less energy-consumptive than from virgin sources.

This report covers the preliminary steps required for the development of a regional resource recovery system, and includes the results of a detailed study of the following aspects of the proposed system:

1. Waste sampling studies.
2. Economic analysis considering site location, transportation, and use of SWDF as a fuel.
3. Conceptual and preliminary design and cost study of a processing plant.
4. Sale of various waste stream constituents.
5. Conceptual and preliminary design of the required power plant modifications.
6. Power plant technical problems.
7. Gasification of MSW as an alternative.
8. Environmental evaluation and compliance studies.

SECTION IV

STUDY ASSUMPTIONS

The following are some of the assumptions upon which this study was based:

- Financing of capital costs are considered at annual rates of 8-1/2 percent and 10 percent under the presumption that TVA would finance such an operation using either power or appropriated funds. Tables 14-13 and 14-14 illustrate the impact of alternative financing which might permit a rate as low as 7 percent.

- All cost figures are expressed in 1977 dollars.

- Time periods for economic evaluations are 10, 15, and 20 years starting July 1, 1979.

- Use of wood waste and hazardous waste is not considered in Phase I.

- The price TVA could pay for SWDF at each specific plant selected is based on economic load dispatch, the present and projected coal prices, and the added cost of ash disposal. Amortization of capital costs and added O&M costs also influence this price.

- SWDF output of the 1,000-ton-per-day (input) plant operating five days per week on a 16-hour shift basis is as follows:

Maximum particle size	3/4 inch
90 percent of particle size	less than 1/2 inch
Heat content of SWDF	6,000 Btu per pound

- Power plant modification cost estimates for capital and O&M costs based on Btu inputs of 10 percent, with a capability of 20 percent.

- Technical problem studies include, but are not limited to, investigations of possible problems in the areas of:

a. Boiler corrosion
b. Electrostatic precipitator efficiency
c. Bottom ash fallout
d. Hazardous gas from pressurized boilers

- Three different gasification processing plant capacities are analyzed (700 TPD, 1,400 TPD, and 2,100 TPD). Their operation is based on a 7-day-per-week, three-shift-per-day basis.

SECTION V

SOLID WASTE SUPPLY AND AVAILABILITY

This section of the report was prepared by TVA's Office of Tributary Area Development.

Inventory of Solid Waste Supplies

Since solid waste is the raw material for a resource recovery system, it is essential to have a good understanding of the location, volume, and characterization of the waste. The supply of solid waste for a regional resource recovery system depends primarily on how much waste is collected in the region and the locations of the major collection service areas. Approximately 21,600 tons of solid waste materials are generated daily by the 6.7 million people residing in the TVA power service area. Of this amount, only about 51 percent is presently being collected by public or private waste collection systems. The remaining waste is burned or dumped at random locations and is not now available as a solid waste supply. Too, certain solid waste materials cannot be accepted at the waste processing plant and should be excluded from consideration. These include agricultural and mining wastes, demolition and construction materials, and certain industrial wastes.

A county-by-county survey was conducted during the period October 1974 through January 1975 to determine the quantities of solid waste being collected in the TVA power service area and to locate the major concentration points of disposal for these wastes. The primary purpose of this inventory was to obtain data for the sizing and location analyses of waste processing plants and the waste transportation networks.

The survey was initiated by collecting information on solid waste collection systems and disposal facilities operating in the 201-county region. Solid waste officials in each of the Valley's state governments provided information regarding sanitary landfill locations, their approximate service areas, and the operating entities. Where available, similar information was provided on collection systems operating in each county. Regional planning and development districts and councils of governments provided regional solid waste management plans, waste surveys, and other pertinent information. Records from landfill operations utilizing weighing scales were obtained and used as direct inputs to the solid waste inventory. Because so few landfill operations have weighing facilities, it was necessary to formulate a standardized procedure for estimating quantities of wastes being collected in most counties.

Methods for Estimating Waste Quantities

The procedure used for estimating waste quantities was based on observed levels of effectiveness for several types of collection systems. Weight records from various landfill and waste collection operations showed that a fairly constant relationship exists between the average annual tonnage collected by specific types of waste collection services and the population in the geographical areas that are served. This numerical relationship, termed "waste load factor," was derived for specific types of collection systems by using the following expression:

$$\text{Waste load factor (lbs./person/day)} = \frac{\text{annual tons collected}}{\text{population of service area}} \times \frac{2000}{365}$$

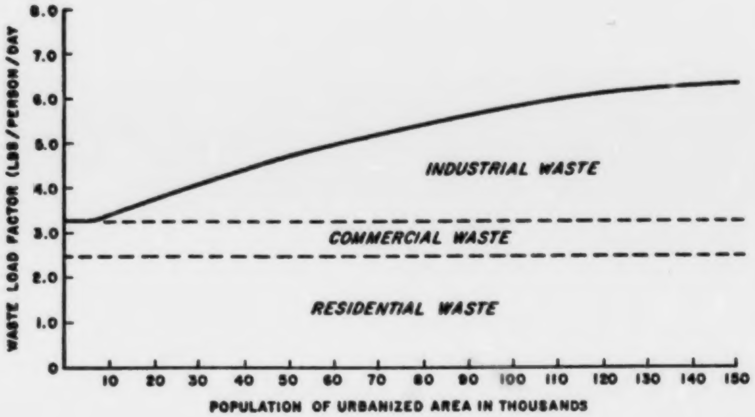
On the basis of similar waste load factors, all collection systems in the region were classified according to the following categories:

1. Bulk container collection in unincorporated area (WLF = 1.5).
2. Bulk container collection in incorporated areas (WLF = 2.0).
3. Contracted residential collection in unincorporated areas (WLF = 2.5).
4. Municipal collection services (WLF = variable from 3.3 to 6.4).

Waste quantities collected by municipal systems were found to vary with the size of the urbanized area, possibly because of the amounts of industrial waste entering the waste stream. Residential and commercial waste loads can be directly related to the population on a per capita basis; however, industrial waste quantities are a function of the size of the population base. For example, the per capita industrial waste load for a city of 25,000 people is about 0.6 pounds per day, whereas for a city of 100,000, it is around 2.5 pounds per day. The curve in Figure 5-1 which was extrapolated from survey data illustrates this variation and was used to derive waste load factor for incorporated towns and cities.

Waste quantities were calculated for each of the 201 counties and were adjusted for those counties having records of actual waste tonnages received and for some other counties where local estimates grossly differed from TVA's calculated values. A sample calculation for a typical county is given in Figure 5-1. The waste inventory summary is given in Table 5-1.

WASTE LOAD FACTOR CURVE FOR MUNICIPAL COLLECTION SYSTEMS



SAMPLE CALCULATION OF WASTE QUANTITY FOR A TYPICAL COUNTY

County Municipality	Population 1970 Census	Type of Collection Service	Waste Load Factor (Lbs./cap./day)	Waste Amount (Tons Per Week)
Anderson Co.	23,187	2 % Contract Residential	2.5	3.5
		98 % Rural Bulk Container	1.5	119.6
Clinton	4,794	Municipal	3.32	55.7
Lake City	1,923	Municipal	3.32	22.4
Norris	1,359	Municipal	3.32	15.6
Oak Ridge	26,829	Municipal	4.02*	377.5
Oliver Springs	2,208	Municipal	3.32	25.6
				Total 619.9 tons/week

*Oak Ridge urbanized area includes 1,490 people in adjacent Roane County for a total of 28,319.

Figure 5-1

TABLE 5-1

SOLID WASTE QUANTITIES
In The
TENNESSEE VALLEY REGION

Summary Table

State County	1970 Population	Tons Per Week
Alabama		
Blount	26,853	127.6
Cherokee	15,606	98.1
Colbert	49,632	622.7
Cullman	52,445	347.2
De Kalb	41,981	250.3
Etowah	94,144	1224.8
Franklin	23,933	203.6
Jackson	39,202	240.4
Lauderdale	68,111	764.2
Lawrence	27,281	179.3
Limestone	41,699	324.2
Madison	186,540	4525.5
Marion	23,788	158.7
Marshall	54,211	392.2
Morgan	77,306	841.8
Winston	16,654	137.8
Georgia		
Catoosa	28,271	101.5
Chattooga	20,541	159.0
Dade	9,910	61.7
Fannin	13,357	49.8
Gilmer	8,956	27.3
Gordon	23,570	85.9
Lumpkin	8,728	41.5
Murray	12,986	54.6
Georgia (cont.)		
Rabun	8,327	41.5
Towns	4,565	17.5
Union	6,811	16.8
Walker	50,691	298.7
Whitfield	55,108	386.3
Kentucky		
Allen	12,598	46.4
Butler	9,723	8.5
Calloway	27,692	179.2
Carlisle	5,354	14.9
Christian	56,224	469.3
Cumberland	6,850	24.5
Edmonson	8,751	59.5
Fulton	10,183	76.6
Graves	30,939	147.2
Grayson	16,445	59.2
Hickman	6,264	45.5
Livingston	7,596	10.0
Logan	21,793	108.3
Lyon	5,562	31.0
McCracken	58,281	643.7
Marshall	20,381	143.7
Monroe	11,642	39.9
Simpson	13,054	82.5
Todd	10,823	12.5

Summary Table, SOLID WASTE QUANTITIES (cont.) TABLE 5-1
Page 2 of 4

State County	1970 Population	Tons Per Week
Kentucky (cont.)		
Trigg	8,620	28.9
Warren	57,432	676.6
Mississippi		
Alcorn	27,179	171.5
Attala	19,570	155.9
Benton	7,505	14.1
Calhoun	14,623	69.9
Chickasaw	16,805	83.1
Choctaw	8,440	29.7
Clay	18,840	112.6
Itawamba	16,847	46.5
Kemper	10,233	20.5
Lafayette	24,181	180.1
Leake	17,085	113.0
Lee	46,148	989.0
Lowndes	49,700	479.8
Marshall	24,027	90.7
Monroe	34,043	281.9
Neshoba	20,802	86.7
Noxubee	14,288	51.1
Oktibbeha	28,752	234.4
Panola	26,829	111.3
Pontotoc	17,363	121.5
Prentiss	20,133	94.2
Scott	21,369	158.2
Tallahatchie	19,338	72.9
Tate	18,544	77.5
Tippah	15,852	63.5
Tishomingo	14,940	59.3
Union	19,096	175.0
Webster	10,047	33.2
Winston	18,406	94.4
Yalobusha	11,915	56.7

State County	1970 Population	Tons Per Week
North Carolina		
Avery	12,655	79.5
Buncombe	145,056	1,550.9
Cherokee	16,330	107.4
Clay	5,180	5.0
Graham	6,562	39.4
Haywood	41,710	310.5
Henderson	42,804	201.2
Jackson	21,593	120.0
Macon	15,788	101.5
Madison	16,003	104.8
Mitchell	13,447	88.1
Swain	7,861	121.4
Transylvania	19,713	78.3
Watauga	23,404	185.8
Yancey	12,629	74.9
Tennessee		
Anderson	60,300	619.7
Bedford	25,039	212.8
Benton	12,126	86.5
Bledsoe	7,643	49.4
Blount	63,744	600.0
Bradley	50,686	382.6
Campbell	26,045	204.7
Cannon	8,467	28.2
Carroll	25,741	161.5
Carter	43,259	180.7
Cheatham	13,199	84.2
Chester	9,[illegible]27	50.2
Claiborne	19,420	122.9
Clay	6,624	20.5
Cocke	25,283	114.3
Coffee	32,572	318.8
Crockett	14,402	74.4
Cumberland	20,733	145.4

Summary Table, SOLID WASTE QUANTITIES (cont.) TABLE 5-1
Page 3 of 4

State County	1970 Population	Tons Per Week
Tennessee (cont.)		
Davidson	447,877	12,604.7
Decatur	9,457	43.7
DeKalb	11,151	83.1
Dickson	21,977	158.8
Dyer	30,427	230.1
Fayette	22,692	140.1
Fentress	12,593	82.1
Franklin	27,289	167.7
Gibson	47,871	359.5
Giles	22,138	109.1
Grainger	13,948	73.2
Greene	47,630	355.6
Grundy	10,631	80.4
Hamblen	38,696	425.3
Hamilton	254,236	3,970.8
Hancock	6,719	15.3
Hardeman	22,435	116.9
Hardin	18,212	132.3
Hawkins	33,757	253.7
Haywood	19,596	151.1
Henderson	17,360	55.5
Henry	23,749	140.0
Hickman	12,096	38.4
Houston	5,853	24.8
Humphreys	13,560	109.4
Jackson	8,141	19.0
Jefferson	24,940	181.6
Johnson	11,569	72.7
Knox	276,293	4,266.8
Lake	8,091	50.9
Lauderdale	20,271	106.3
Lawrence	29,097	166.0
Lewis	6,761	42.3
Lincoln	24,318	101.5
Loudon	24,266	135.1

State County	1970 Population	Tons Per Week
Tennessee (cont.)		
McMinn	35,462	252.8
McNairy	18,369	135.1
Macon	12,315	46.3
Madison	65,774	663.5
Marion	20,577	193.2
Marshall	17,319	290.0
Maury	44,028	430.8
Meigs	5,219	16.0
Monroe	23,475	95.9
Montgomery	62,721	633.2
Moore	3,568	8.9
Morgan	13,619	77.6
Obion	29,936	231.8
Overton	14,866	45.8
Perry	5,238	39.2
Pickett	3,774	9.6
Polk	11,669	21.8
Putnam	35,487	267.6
Rhea	17,202	135.3
Roane	38,881	401.0
Robertson	29,102	245.1
Rutherford	59,428	534.0
Scott	14,762	44.5
Sequatchie	6,331	43.9
Sevier	28,241	220.0
Shelby	722,111	14,627.8
Smith	12,509	53.4
Stewart	7,319	41.0
Sullivan	127,329	1,098.2
Sumner	56,284	398.1
Tipton	28,001	197.7
Trousdale	5,155	28.6
Unicoi	15,254	110.1
Union	9,072	7.9
Van Buren	3,758	27.2

Summary Table, SOLID WASTE QUANTITIES (cont.)   TABLE 5-1
Page 4 of 4

State County	1970 Population	Tons Per Week	State County	1970 Population	Tons Per Week
Tennessee (cont.)					
Warren	26,972	152.2			
Washington	73,924	767.6			
Wayne	12,365	50.0			
Weakley	28,827	183.0			
White	16,355	117.3			
Williamson	34,423	287.8			
Wilson	36,999	296.7			
Virginia					
Bland	5,423	54.7			
Dickenson	16,077	105.6			
Grayson	15,439	214.0			
Lee	20,321	125.5			
Russell	24,533	151.3			
Scott	24,376	170.9			
Smyth	31,349	241.2			
Tazewell	39,816	312.9			
Washington	55,692	506.3			
Wise	40,119	323.3			
Wythe	22,139	166.4			

ETDD Solid Waste Weighing Program

The East Tennessee Development District conducted a solid waste weighing program in its 16-county region to refine the waste load estimates for the area. Solid waste coming into 12 waste-handling facilities (sanitary landfills and transfer stations) in their district was weighed and classified for a period of one week. Weighing was accomplished at each site using portable scales or the site's weighing facilities. The results of this weight sampling program are given in Table 5-2. TVA's calculated estimates for the same areas are included for comparison. Overall, the weighed amounts and the calculated estimates compared closely: 6,112.2 tons per week to 7,140.7 tons per week, respectively. The 17 percent difference in the two values can be accounted for in that the weighing was accomplished during the winter months when waste generation is at its minimum and during a period of economic depression in the region.

Analysis of Available Solid Waste Supplies

The fact that over 21,000 tons of solid waste is being generated each day in the region does not mean all of this waste is being collected and consequently would be an available supply for a TVA waste processing system. Neither can it be assumed that all waste materials being collected could be considered as a guaranteed supply. The final disposition (as well as the availability) of collected waste materials remains, to a great extent, under the control of the local governments. All potential sources of solid waste supplies depend upon decisions to be made at some point in the future by the local entities. These decisions will naturally be influenced by the economies associated with the continuance of their present disposal operation or their participation in a resource recovery project.

Under the present resource recovery concept, participating local governments would have the responsibilities of constructing and operating area transfer stations while maintaining backup sanitary landfills. Some entities will be able to realize significant cost savings through reduced landfill operation costs, increased landfill life, and possible reduced collection costs. On the other hand, some entities would not be benefited if the costs involved with owning and operating a transfer station exceed the savings that could otherwise be realized. In other words, the reduction in landfill operation costs would need to be nearly equal to or less than the added costs of owning and operating a transfer station.

Two cost studies were independently performed by TVA and the East Tennessee Development District to determine which local governments would be most likely to participate in the regional system. Owning and operating costs for sanitary landfills and for minimum-size transfer stations were compared for various

TABLE 5-2
EAST TENNESSEE DEVELOPMENT DISTRICT
SUMMARY RESULTS OF SOLID WASTE WEIGHING PROGRAM

County Sampling Location	Waste Received (tons)						Total Tons Per Week	TVA Estimate (tons/wk.)
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday		
Anderson Co., TN								
Oak Ridge Landfill	44.0	42.2	37.8	33.5	28.4	29.5	215.4	
Anderson Co. Landfill	46.9	27.8	40.6	24.2	30.0	14.4	183.9	
							399.3	619.9
Blount Co., TN								
Maryville-Aloca-Blount County Landfill	135.8	105.1	110.1	97.2	100.6	50.7	599.5	432.4
Campbell Co., TN								
Campbell Co. Landfill	38.6	33.3	23.7	36.0	26.2	5.0	162.8	204.7
Claiborne Co., TN								
Claiborne Co. Landfill	39.7	17.6	15.4	21.4	17.9	2.7	114.7	122.9
Sevier Co., TN								
Gatlinburg Landfill	17.9	28.5	29.4	18.9	29.7	7.1	131.5	220.3
Jefferson Co., TN								
Jefferson Co. Landfill	33.4	34.2	16.3	26.1	22.8	12.9	145.7	181.6
Knox Co., TN								
Knoxville Transfer Station	540.5	543.7	548.9	492.1	373.4	53.9	2622.7	
Knoxville Landfill	150.0	150.0	150.0	150.0	150.0	50.0	800.0	4266.8
							3422.7	
Loudon Co., TN								
Loudon Transfer Station	21.5	22.4	21.2	18.7	19.2	10.5	113.5	135.1
Hamblen Co., TN								
Morristown-Hamblen Co. Landfill	97.9	84.8	73.3	102.5	71.9	-	429.9	425.3
Cocke Co., TN								
Newport Transfer Station	38.5	26.0	22.3	24.6	33.2	8.5	153.1	114.3

TABLE 5-2

EAST TENNESSEE DEVELOPMENT DISTRICT

SUMMARY RESULTS OF SOLID WASTE WEIGHING PROGRAM (CONT.)

County Sampling Location	Waste Received (tons)						Total Tons Per Week	TVA Estimate (tons/wk.)
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday		
Morgan Co., TN Roane Co. Landfill	15.0	9.5	15.6	8.1	8.4	-	56.5	77.6
Roane Co., TN Roane Co. Landfill	83.4	64.4	65.7	66.6	69.4	33.6	383.0	339.8

sized waste disposal operations. A minimum-size transfer station was designed by TVA which would cost around $80,000 to construct and approximately $13,200 per year to operate (See Figure 5-2). Assuming a 9 percent interest rate for a period of 15 years, the capital investment could be amortized at about $9,900 per year for a total annual cost of $23,100. To be economically feasible, the landfilling costs for a 35-ton-per-day operation would therefore have to be reduced by at least $2.12 per ton of waste. The cost study by TVA indicated that these owning and operating costs could be absorbed by local disposal entities handling 40 tons or more per day. ETDD estimated the point of economic indifference to be around 30 tons per day. Because ETDD used more recent cost surveys and estimates, the 30-ton-per-day figure was assumed as the minimum quantity in the waste supply analysis.

Based on the minimum-sized operation of 30 tons per day, 98 of the 201 counties in the region were identified as probable participants in a regional system. These counties are shown on the map in Figure 5-3. From these counties, approximately 45,000 tons per week could be considered as a solid waste supply.

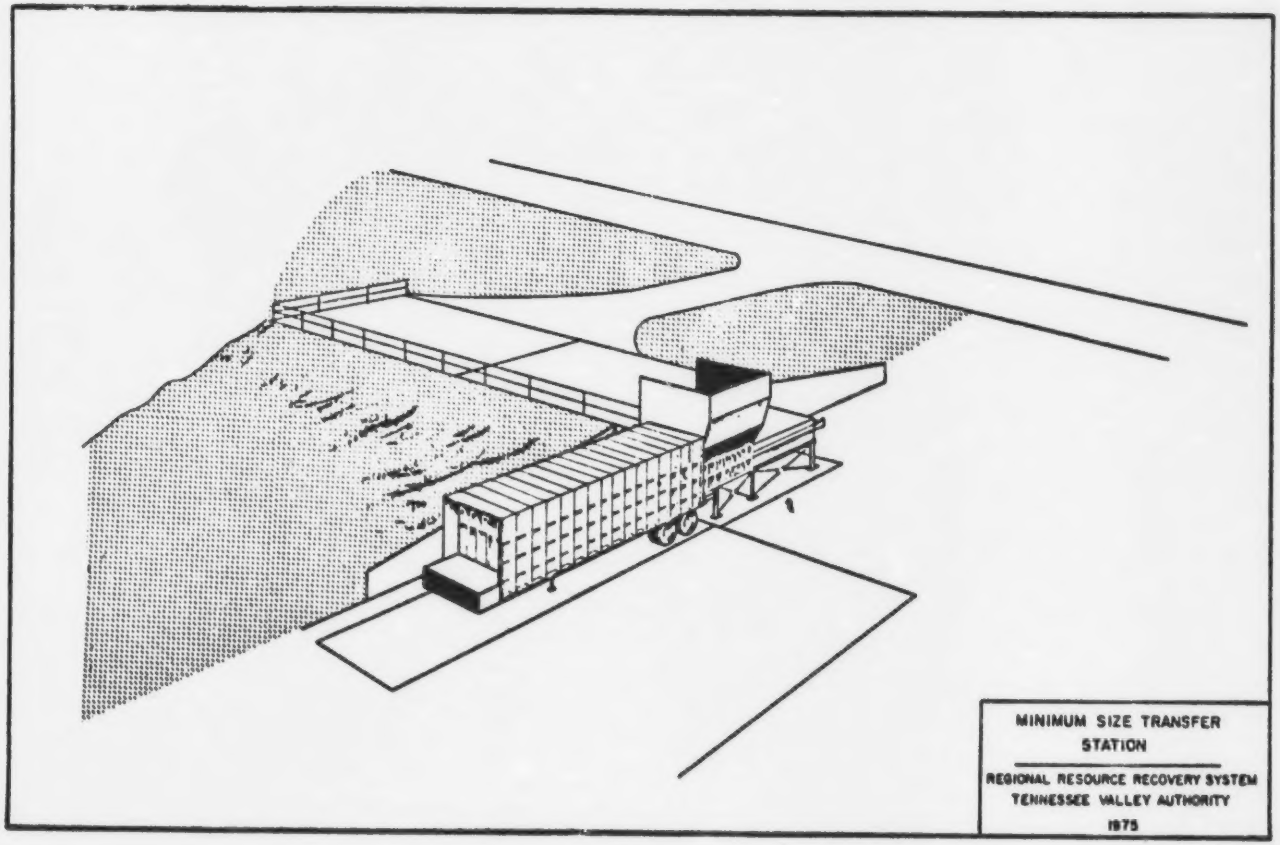
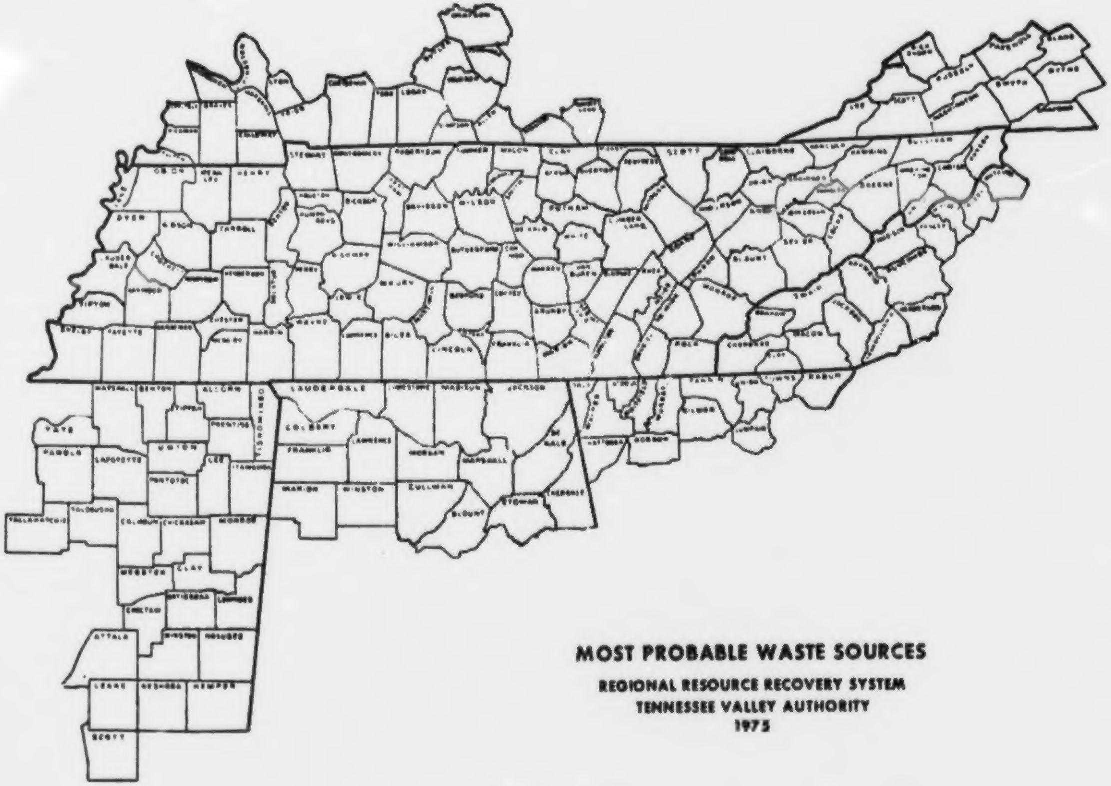

MINIMUM SIZE TRANSFER STATION
REGIONAL RESOURCE RECOVERY SYSTEM
TENNESSEE VALLEY AUTHORITY
1975

Figure 5-2


STEWART
ROBERTSON
SUMNER
MACON
CLAY
SCOTT
CLAIBORNE
HANCOCK
HAWKINS
SULLIVAN
OBION
WEAKLEY
HENRY
DYER
GIBSON
CARROLL
HOUSTON
DICKSON
HUMPHREYS
DAVIDSON
WILSON
PUTNAM
DE KALB
WHITE
CUMBERLAND
GREENE
LAUDERDALE
HAYWOOD
TIPTON
WILLIAMSON
RUTHERFORD
CANNON
WARREN
VAN BUREN
MAURY
LEWIS
BEDFORD
COFFEE
GRUNDY
BLOUNT
SEVIER
MONROE
COCKE
POLK
CHESTER
HARDIN
WAYNE
LAWRENCE
GILES
LINCOLN
FRANKLIN
SHELBY
FAYETTE
McNAIRY
MARION
SMITH
CHEROKEE
MACON
RABUN
GILMER
LUMPKIN
GORDON
DE KALB
LEE
SCOTT
WISE
RUSSELL
SMYTH
WYTHE
BLAND
TAZEWELL
BUCHANAN
DICKENSON
WASHINGTON
MARSHALL
BENTON
ALCORN
TISHOMINGO
TIPPAH
PRENTISS
TATE
PANOLA
LAFAYETTE
UNION
LEE
ITAWAMBA
PONTOTOC
TALLAHATCHIE
YALOBUSHA
CALHOUN
CHICKASAW
MONROE
WEBSTER
CLAY
OKTIBBEHA
LOWNDES
CHOCTAW
ATTALA
WINSTON
NOXUBEE
LEAKE
NESHOBA
KEMPER
SCOTT
LAUDERDALE
LIMESTONE
MADISON
JACKSON
COLBERT
LAWRENCE
FRANKLIN
MORGAN
MARSHALL
MARION
WINSTON
CULLMAN
BLOUNT
ETOWAH
CHEROKEE
DE KALB

MOST PROBABLE WASTE SOURCES
REGIONAL RESOURCE RECOVERY SYSTEM
TENNESSEE VALLEY AUTHORITY
1975

Figure 5-3

SECTION VI

TRANSPORTATION, SITE LOCATION OR PROCESSING PLANT, STORAGE, AND HANDLING

General Considerations for Locating Processing Plants

The original concept for the regional resource recovery system project involved locating waste processing plants in as many as nine major cities throughout the TVA region (Figure 6-1). Each city would be responsible for delivering its waste to the TVA processing plant free of charge; TVA likewise would charge no dumping fee. To ensure that all municipalities would have an opportunity to participate in the system on an equal basis, outlying counties would be responsible for collecting, owning, and operating a central transfer station and maintaining a backup landfill. TVA would then bear the cost of transporting the waste from these transfer stations to the waste processing plant.

As a result of studies previously discussed, it was determined that only those counties collecting more than 30 tons of waste per day should be considered for general planning purposes. The designing of the transportation networks to serve these counties and locating of the processing plants were primarily dependent upon the location of the facilities that would receive the fuel product. This is because over 50 percent of the recovered product is fuel. Early studies indicated that only two power plants would likely be selected for use--one to serve the east end of the region (either Kingston or Bull Run) and one to serve the west end of the region (either Colbert or Cumberland). It also appeared that Knoxville was well situated for a heat recovery incineration unit. Colbert was eliminated because of its low capacity and value that could be assigned to the solid waste derived fuel. This left Cumberland to serve the west and either Kingston or Bull Run to serve the east. At a 10 percent firing rate, these plants can burn solid waste derived fuel at the following rates:

Cumberland - 3,300 tons per day
Kingston - 1,500 tons per day
Bull Run - 1,400 tons per day

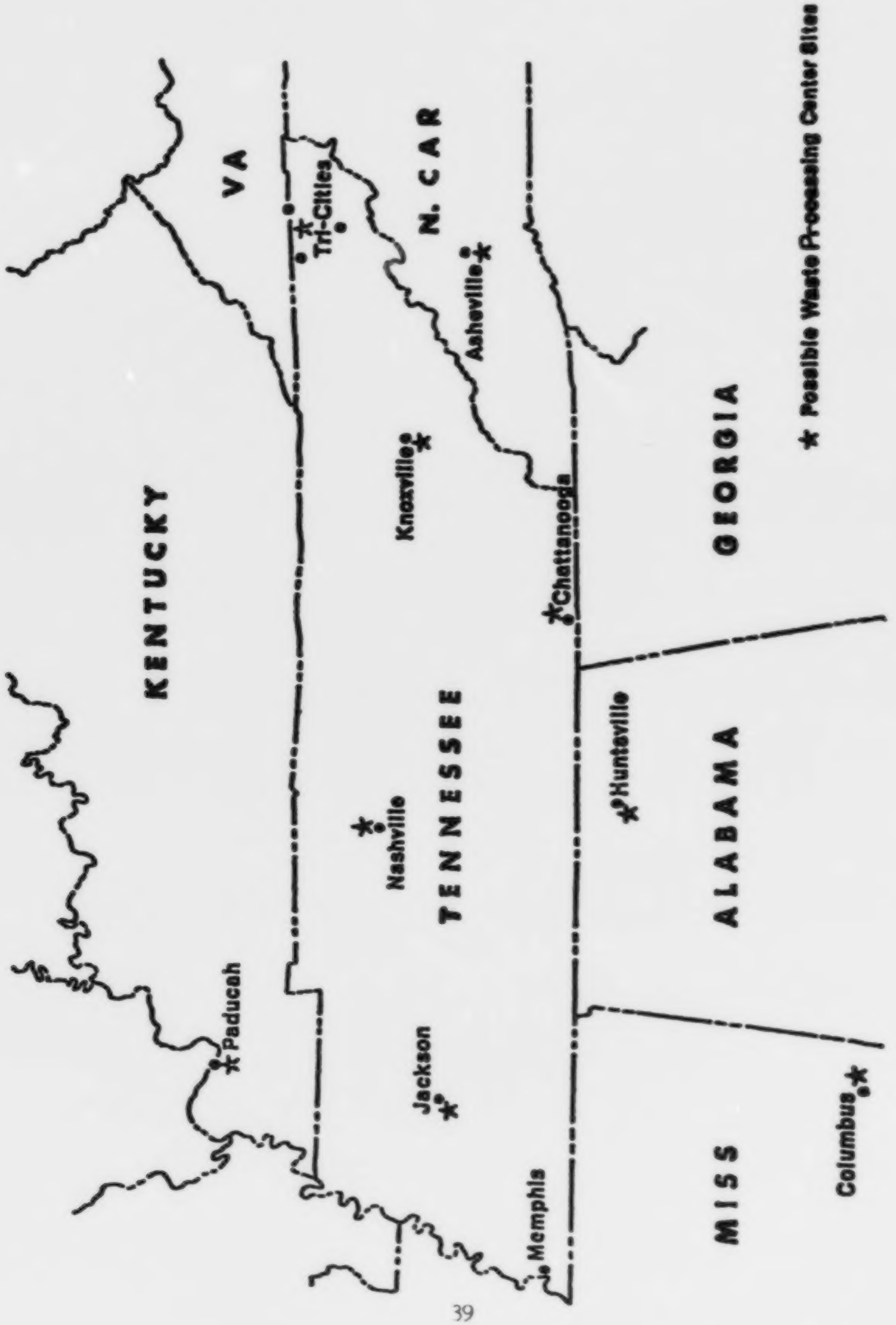

KENTUCKY
VA
N. CAR
TENNESSEE
GEORGIA
ALABAMA
MISS
Paducah
Tri-Cities
Asheville
Knoxville
Chattanooga
Nashville
Huntsville
Jackson
Memphis
Columbus
★ Possible Waste Processing Center Sites

Figure 6-1

Service districts for these plants are then necessarily limited to the amount of waste generated that would produce this quantity of fuel fraction. The basic assumption is that 54 percent of the waste processed can be recovered as a supplemental fuel product. The inventory of waste quantities in the region coupled with incremental transportation cost analysis shows that the Kingston-Bull Run service district should extend no farther west than Chattanooga and its immediate vicinity. Thus, power plant service districts were set--the Kingston-Bull Run district would include Chattanooga, Knoxville, Tri-Cities, and Asheville; the Cumberland district would include the remainder of the region.

After establishing service district limits, studies were made to determine the number and location of processing plants that would be needed to serve each area. Many alternatives were investigated. The most economical scheme, however, appeared to be that of locating a single processing plant in each service district. This plant would be located in the largest city near the facility to be used for consuming the fuel fraction. Many of the processing plants considered in the original concept would be replaced by regional transfer stations that would allow shipment of waste on to the central processing plants. Figure 6-2 shows tentative locations selected for the two processing plants, Knoxville in the east service district and Nashville in the west district.

The optimum locations of the fuel users other than the steam plants coincide with the general areas of the proposed power plants. It appears that the Knoxville area is well situated for heat recovery incineration for fuel utilization, and that the Nashville area is acceptable for waste gasification of the fuel product.

In selecting these sites, consideration was first given to locating the central processing facility at the power plant to be modified; however, many factors effected a decision not to proceed with this approach.

1. The processing plant is an industrial operation that requires water, sewer, electricity, and all the basic utilities that can be found in major city industrial parks.

2. Land availability at power plants selected is limited.

3. Satellite industries such as detinning companies or heavy media separation plants that need to be located adjacent to the processing facility will require considerable land base and industrial park services.

4. Locating the processing center at the major waste source, such as Knoxville or Nashville, allows for free delivery of the city's waste to the processing plant.

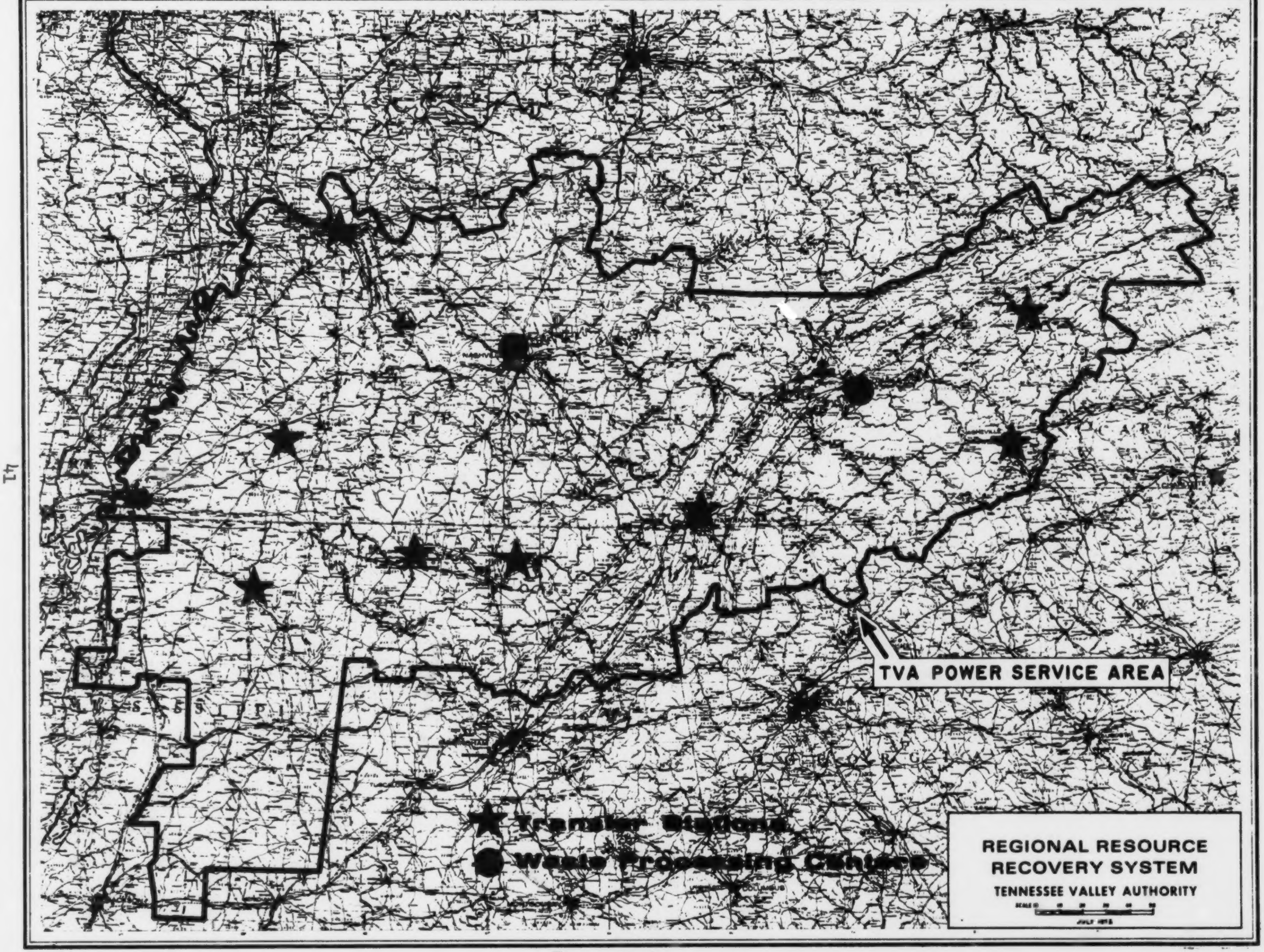

TVA POWER SERVICE AREA
Transfer Stations
Waste Processing Centers
REGIONAL RESOURCE
RECOVERY SYSTEM
TENNESSEE VALLEY AUTHORITY

Figure 6-2

Elements of the Transportation Network

The transportation network serving locally owned transfer stations consists of over-the-road equipment that could be owned and operated by TVA. Such equipment would consist of 75-cubic-yard transfer trailers and 4 x 6 tractors, which are capable of carrying the maximum legal payload of approximately 19 tons.

Each local transfer station would be provided an adequate number of transfer trailers for temporary storage and would be serviced daily. Raw waste would be transported from the local stations to the processing plant or a regional transfer station, whichever is the closer. Though most over-the-road hauls are less than 80 miles one way, the maximum distance that this system can effectively operate is around 130 miles.

Transporting solid waste from regional transfer stations to the processing plants is generally uneconomical for over-the-road equipment due to the long haul distances and the large tonnages involved. For this element of the transportation network, rail haul and barge haul alternatives were investigated.

Barge haul, unlike truck haul, involves moving large quantities of materials at a slow speed. For a continuous flowing system, such as the generation and collection of solid waste, barge hauling is not feasible because of the necessary increased storage requirements. In addition, the costs for handling facilities required for barge transport, such as loading and unloading terminals, make the barge alternative uneconomical in comparison to other transportation modes. Though long-distance hauling by barge is relatively uneconomical, barge hauling of the fuel fraction from Nashville's processing plant to the Cumberland Steam Plant might be required because of limited road and rail facilities.

Rail haul provides the capabilities of moving large tonnages of waste in relatively short periods of time and is, therefore, better suited for transporting waste materials from regional transfer stations to the processing plants. Rail haul networks would be based on TVA owning and maintaining the rail cars with the railroad companies furnishing the locomotives and crews. Rail rates would be changed by the train-mile in the cases for dedicated train service or by the car load for line-haul service. Southern Railway would serve the eastern part of the power service area and the L&N Railroad would serve the western area of the Valley.

Four types of rail-haul systems were investigated to determine the most economical method of utilizing the rail services. These are: (1) the container concept which is being developed for the St. Louis resource recovery system; (2) the 170-cubic-yard compactor rail car which maximizes the payload per rail car; (3) the "piggy back" concept of hauling two over-the-road transfer trailers on a flatbed car; and (4) the rotary discharge hopper car system which is used by coal and wood chip haulers.

The three principle elements that determine the cost of rail haul are car costs, track rates, and handling (loading and unloading) costs. An economic analysis was performed on the four types of rail-haul systems and the results are summarized below. The analysis indicates the rotary discharge hopper car concept to be the most economical approach. Studies performed by TVA have indicated that a 7,000 cubic foot rotary discharged car could carry an average of 45 tons of raw waste in uncompacted form to the processing plants. Tests at the City of Knoxville transfer station show densities of approximately 350 pounds per cubic yard can be expected in this type car. Figures 6-3 and 6-4 illustrate a typical rotary discharge rail car and transfer station, respectively.

COST COMPARISON OF RAIL-HAUL ALTERNATIVES

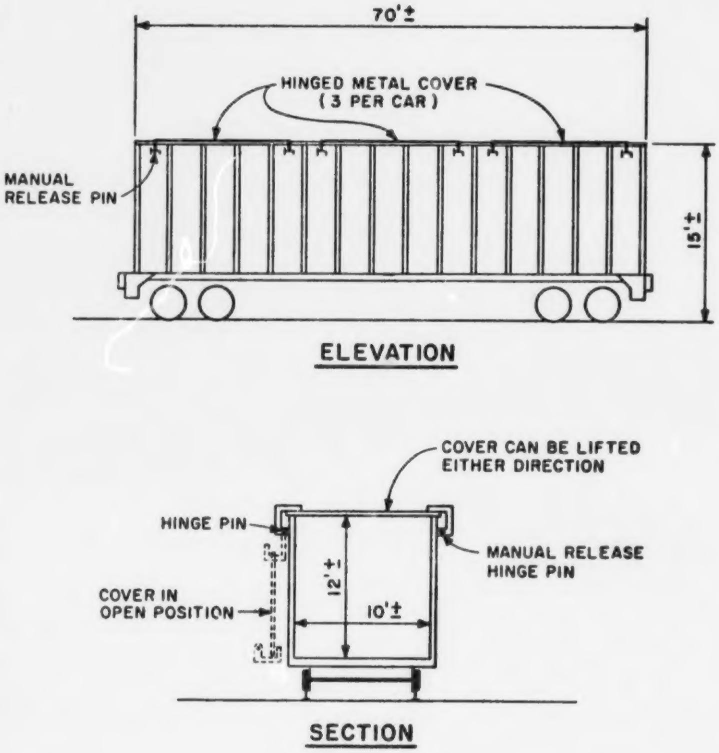
Case 1: One-way haul distance = 150 miles; 3,600 tons per week transported in three shipments; dedicated train service; 3,000 tons per day processing plant; all costs reduced to average annual figures

Rail System	Rail Container	Compaction Car	"Piggy Back"	Rotary Discharge Car
Loading Facilities	$419,300	$392,800	$214,300	$285,900
Car Costs	552,000	520,000	847,500	245,700
Truck Rates (train mile)	819,000	819,000	819,000	819,000
Unloading Facilities	79,900	65,800	77,300	96,000
Cost Per Ton	9.99	9.60	10.46	7.73

Transportation Analysis

Transportation networks were analyzed for each of the two power plant service districts as described below.

Since transportation costs are dependent upon the quantities and sources of solid waste, the network analyses must account for the period between the startup of the processing plants and the time the system reaches design capacity. The duration of this


70'±
HINGED METAL COVER
(3 PER CAR)
MANUAL
RELEASE PIN
15'±
ELEVATION
COVER CAN BE LIFTED
EITHER DIRECTION
HINGE PIN
MANUAL RELEASE
HINGE PIN
COVER IN
OPEN POSITION
12'±
10'±
SECTION

CAPACITY – 8000 CU. FT.±
PAYLOAD – 40 TO 50 TONS
LOOSE REFUSE DENSITY – 300 TO 350 LBS PER C.Y.

ROTARY DISCHARGE
HOPPER CAR
REGIONAL RESOURCE
RECOVERY SYSTEM
TENNESSEE VALLEY AUTHORITY
1975

Figure 6-3

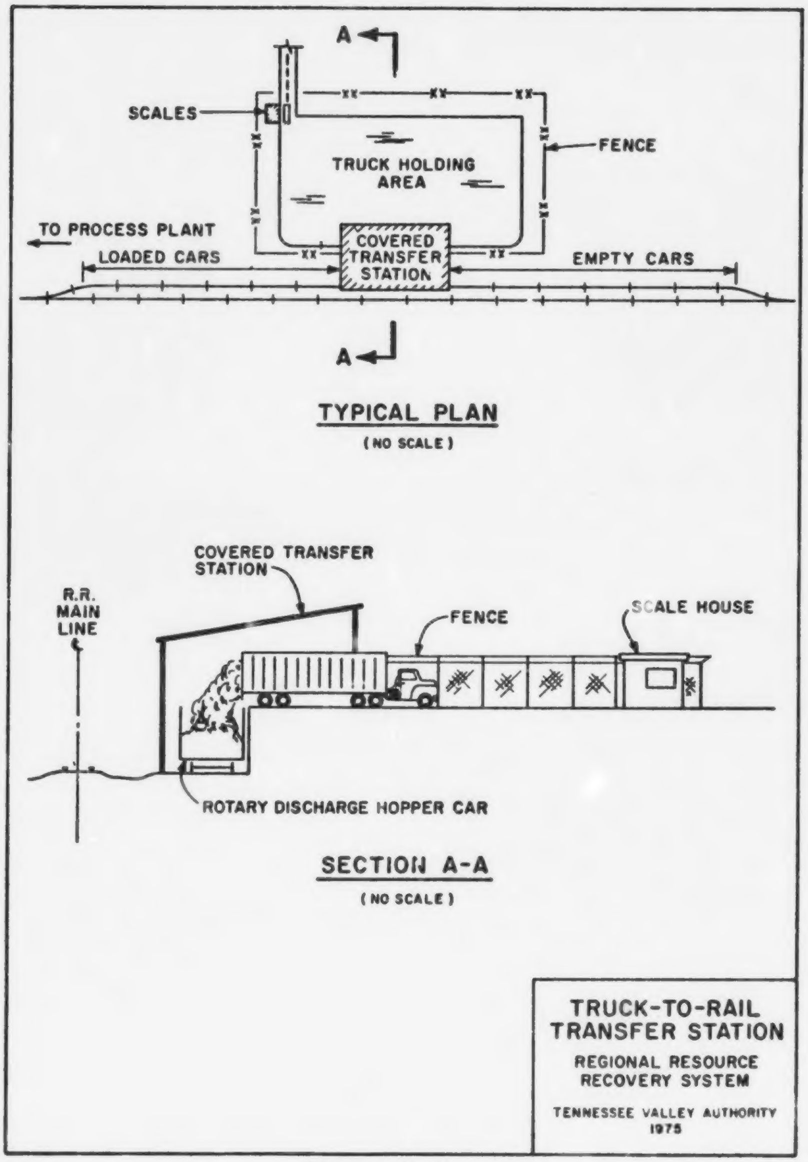

A
SCALES
FENCE
TRUCK HOLDING AREA
TO PROCESS PLANT
COVERED TRANSFER STATION
LOADED CARS
EMPTY CARS
A
TYPICAL PLAN
(NO SCALE)
COVERED TRANSFER STATION
R.R. MAIN LINE
FENCE
SCALE HOUSE
ROTARY DISCHARGE HOPPER CAR
SECTION A-A
(NO SCALE)
TRUCK-TO-RAIL TRANSFER STATION
REGIONAL RESOURCE RECOVERY SYSTEM
TENNESSEE VALLEY AUTHORITY
1975

Figure 6-4

interim period will depend entirely on how soon local governments meet the requirements to participate in the regional system. Two periods of time were considered in designing the transportation network: 1. Stage I as that time when the system is placed into operation and 2. Stage II as that time the system can be considered fully developed. Stage I operations will be based on waste quantities that are essentially guaranteed without any major expenditure being required of local governments. Such waste quantities can be delivered directly to processing plants and regional transfer stations by the large population areas with little change in their normal day-to-day operations. Stage II includes waste quantities coming from the local governments considered as most probable to participate in the regional system.

Kingston-Bull Run Wasteshed--The transportation costs for the Kingston-Bull Run service districts were derived from the following assumptions:

1. A 14,000 ton-per-week waste processing facility would be located in Knoxville.

2. Raw waste would be delivered to the Knoxville processing plant by rail from Chattanooga, Asheville, and Tri-Cities. (A map showing the proposed rail haul scheme is shown in Figure 6-2.)

3. TVA would own regional transfer stations at the three locations shown in Figure 6-2.

4. TVA would serve locally owned transfer stations in outlying counties and deliver waste to the regional transfer stations.

5. Southern Railway would provide service to Chattanooga on Tuesday, Thursday, and Saturday; Tri-Cities on Monday, Wednesday, and Friday; and Asheville on Tuesday and Thursday.

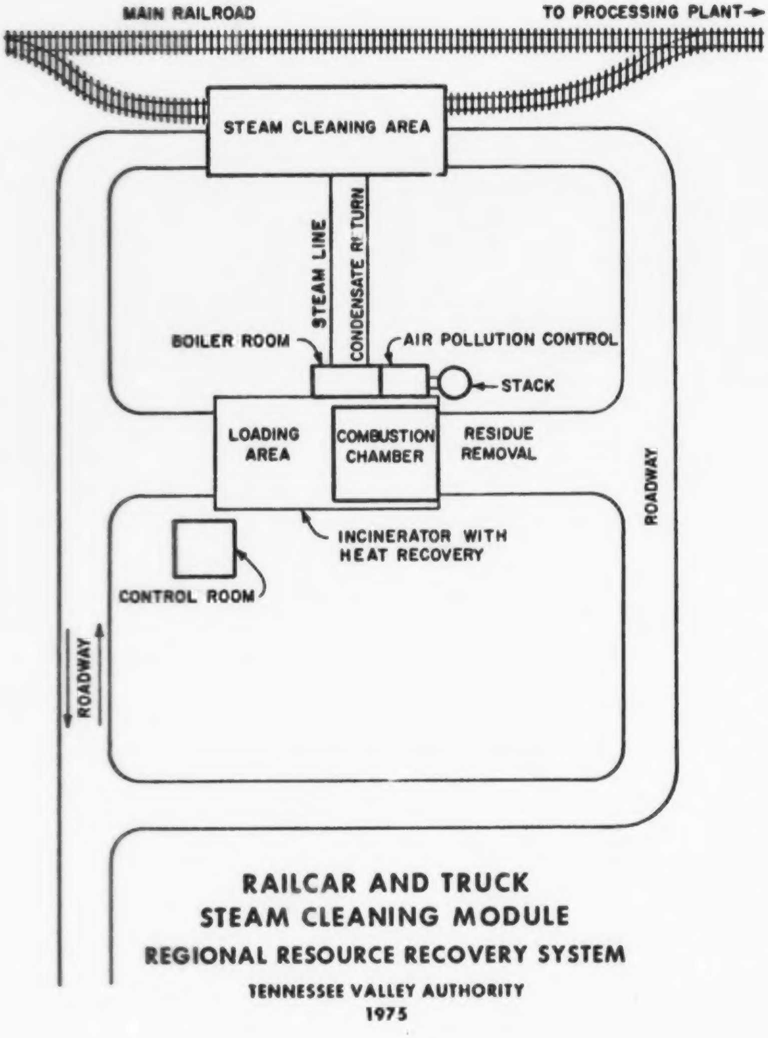
6. Train weight limits for the three routes would be as follows:

   Tri-Cities - 3,300 tons per trip
   Asheville - 3,520 tons per trip
   Chattanooga - 6,380 tons per trip

7. The fuel product would be delivered to Bull Run by truck and Kingston by rail.

8. A cost for maintaining and steam cleaning the rail cars has been included. (See Figure 6-5 for typical plan of car-cleaning module.)

A summary of transportation costs for this service district is shown in Tables 6-1 and 6-2.


MAIN RAILROAD
TO PROCESSING PLANT→
STEAM CLEANING AREA
STEAM LINE
CONDENSATE RETURN
BOILER ROOM
AIR POLLUTION CONTROL
←STACK
LOADING AREA
COMBUSTION CHAMBER
RESIDUE REMOVAL
ROADWAY
INCINERATOR WITH HEAT RECOVERY
CONTROL ROOM
ROADWAY

RAILCAR AND TRUCK
STEAM CLEANING MODULE
REGIONAL RESOURCE RECOVERY SYSTEM
TENNESSEE VALLEY AUTHORITY
1975

Figure 6-5

TABLE 6-1

AVERAGE ANNUAL TRANSPORTATION COST SUMMARY - KNOXVILLE WASTE SERVICE REGION

Stage I: Guaranteed Coverage for Initially Developed System

Service Area	Waste Quantity tons/wk	Service Area Transportation Costs	Regional Truck-to-Rail Transfer Station	Transportation Costs to Processing Plant	Dispatch and Cleaning Services	Transportation of Fuel to Steam Plant	Total Average Annual Cost
Asheville, NC	1,550		$254,200	$ 307,900	$198,700	$642,900 (Bull Run)	$3,226,900 ($5.21/ton)
Chattanooga, TN	3,970		254,200	791,000			
Tri-Cities, TN	1,870		309,300	402,600			
Knoxville, TN	4,520	$66,100					
(Subtotals)	11,910	$66,100	$817,700	$1,501,500	$198,700	$642,900	

TABLE 6-2

AVERAGE ANNUAL TRANSPORTATION COST SUMMARY - KNOXVILLE WASTE SERVICE REGION

Stage II: Probable Coverage for Fully Developed System

Service Area	Waste Quantity Tons/Wk	Service Area Transportation Costs	Regional Truck-to-Rail Transfer Station	Transportation Costs to Processing Plant	Dispatch and Cleaning Services	Transportation of Fuel to Steam Plant	Total Average Annual Cost
Asheville, NC	2,063	$ 68,700	$254,200	$ 410,800		Kingston S.P.	Kingston S.P. Option
Chattanooga, TN	5,524	296,700	391,000	871,000		$747,600	5,631,900 ($5.65/ton
Tri Cities, TN	4,083	553,300	309,300	882,500	$198,700	Bull Run S.P.	Bull Run S.P.
Knoxville, TN	7,515	648,100				$681,200	$5,565,500 ($5.58/ton
(Subtotals)	19,185	$1,566,800	$954,500	$2,164,300	$198,700		

According to the summary, the transportation cost per ton of waste processed would be approximately $5.58.

Cumberland Wasteshed--Transportation costs for this service district were determined using the following assumptions:

1. A 3,000-ton-per-day waste processing facility would be constructed in Nashville.

2. Raw waste would be delivered to the Nashville processing plant by rail from the north Alabama area; Paducah, Kentucky area; west Tennessee area; and north Mississippi area. (Figure 6-2 shows the proposed rail haul scheme.)

3. TVA would own regional transfer stations at locations shown in Figure 6-2.

4. TVA would serve locally owned transfer stations in outlying counties and deliver waste to the regional transfer stations.

5. L&N would provide service to these transfer stations at a cost comparable to that quoted by Southern Railway.

6. Train weigh limits in the Cumberland service district appear to be no problem because of the flat terrain.

7. Service would be provided to the north Alabama area three times a week; the north Mississippi, west Tennessee, and Paducah, Kentucky area would receive line haul service. Line haul cars would be carried to a drop point or stagging area near Bruceton on to the processing plant twice a week by the same engine used to serve the north Alabama area.

Tables 6-3 and 6-4 show a summary of transportation cost for this service district. According to the summary, the transportation cost per ton of waste processed would be approximately $6.89.

NOTE

Transportation costs in this section are based on estimates of transfer station construction costs developed by Dempster Brothers, a division of Carrier Corporation. Transfer station construction cost estimates developed by TVA's OEDC are shown in Table 6-5 and were used in computing the transportation costs given in Tables 14-1 through 14-12.

TABLE 6-3

AVERAGE ANNUAL TRANSPORTATION COST SUMMARY - NASHVILLE WASTE SERVICE REGION

Stage I: Guaranteed Coverage for Initially Developed System

Service Area	Waste Quantity tons/wk	Service Area Transportation Costs	Regional Truck-to-Rail Transfer Station	Transportation Costs to Processing Plant	Dispatch and Cleaning Services	Transportation of Fuel to Steam Plant	Total Average Annual Cost
Paducah, KY	644	$ --	$ 129,700	$ 192,100	$198,700	$996,500 (7,600 TPW)	$4,035,700 ($5.51/ton)
Jackson, TN	664	--	254,200	180,700			
Tueplo, MS	989	--	254,200	295,400			
Huntsville, AL	4,439	--	391,000	1,143,200			
Nashville, TN	7,355	--	--	--			
(Subtotals)	14,091	$ --	$1,029,100	$1,811,400	$198,700	$996,500	

TABLE 6-4

AVERAGE ANNUAL TRANSPORTATION COST SUMMARY - NASHVILLE WASTE SERVICE REGION

Stage II: Probable Coverage for Fully Developed System

Service Area	Waste Quantity tons/wk	Service Area Transportation Costs	Regional Truck-to-Rail Transfer Station	Transportation Costs to Processing Plant	Dispatch and Cleaning Services	Transportation of Fuel to Steam Plant
Paducah, KY	1,055	$ 123,300	$ 129,700	$ 315,200		
Jackson, TN	1,436	172,400	254,200	392,800		
Tupelo, MS	2,340	401,000	254,200	698,400	$198,700	$961,000 (13,200TPW)
Huntsville, AL	9,376	1,521,100	391,000	2,414,900		
Nashville, TN	12,167	1,223,700				
(Subtotals)	26,373	$3,441,500	$1,029,100	$3,821,300	$198,700	$961,000

Total Average Annual Cost: $9,451,700

($6.89/ton)

TABLE 6-5

TVA COST ESTIMATES OF TRANSFER STATION COSTS

	($000's)		
Capacity Per 8-Hour Day	1600-tons	1200-tons	800-tons
Land and Land Rights	$ 95	$ 95	$ 95
General Yard Improvements			
Plant Tracks	635	540	385
Other	120	90	60
Transfer Structure	1,065	830	610
Scale, Office, and Employee Building	120	120	120
Car Uncovering and Covering Station, Including Cranes	110	110	110
Truck Scales	30	30	30
Fuel Oil and Gas Storage	160	155	150
Mobile Equipment	670	590	425
Electrical Work	250	230	200
Subtotal	3,270	2,805	2,200
Construction Facilities	330	285	220
Total Direct Construction	3,600	3,090	2,420
Field General Expense	360	310	245
Contingency	735	625	530
Total Field Construction	4,695	4,025	3,195
Engineering Design	140	140	120
Manager's Office - OEDC	15	15	10
CSB - Engineering Group	10	10	10
Personnel	10	10	10
Purchasing	20	20	20
Medical Services	10	10	10
Employee Compensation Benefits	50	50	50
A&G	50	45	35
Interest During Construction	200	175	140
Total Project	$ 5,200[a]	$ 4,500[a]	$ 3,600[a]

(a.) Based on construction during CY 1977.

SECTION VII

PROCESSING PLANT - DESIGN AND COST ESTIMATE

This section of the report defines a conceptual design and provides a cost estimate for a 1,000-ton per 8-hour shift processing plant for municipal solid wastes. The combined efforts of the Architectural, Hydro, and Special Projects Engineering and Design Branches (DED), the Costs and Estimating Staff (CEDC), and the engineering consultant firm of Black, Crow, and Eidsness, Inc., Gainesville, Florida, were responsible for this conceptual design and the estimated cost.

The goals and objectives set forth for this proposed facility are:

A. The establishment of a prototype processing plant to demonstrate the feasibility of a network of solid waste resource recovery facilities throughout the TVA Power Service Area.

B. Recovery of a supplemental fuel supply for use in TVA coal-fired power plants or for methanol production.

C. Reclamation of marketable materials from solid waste which are being discarded in sanitary landfills.

SYSTEM DESIGN DESCRIPTION

Design Criteria and Requirements

The design of the proposed facility was tailored to provide a nominal operational processing capacity of 1,000 tons of municipal solid wastes per 8-hour shift in two identical but independent process lines. Equipment selection was based on a design capacity of 1,200 tons per 8-hour shift to ensure the nominal capacity of 1,000 tons per 8-hour shift. The processing of this solid waste will produce an acceptable shredded fuel material for use in suspension-fired coal burning installations or for methanol production; three marketable fractions which include crude ferrous, massive ferrous, and crude mixed nonferrous; and a crude glass fraction that has no economic value at the present time.

Refinement of crude mixed nonferrous and glass product outputs from these processes, except for the fuel fraction, has been considered only as a future possibility. Additional space within the processing plant for such refinements has not been provided at this time, but could be added if further processing were economically justified.

Drawings of the site plan and the processing plant layout are shown in Figures 7-1 and 7-2 respectively.

System Input

Sampling studies of regional municipal solid waste have been conducted to establish representative percentages of the constituent materials contained in the raw waste (see Table 7-1). These studies provided the basis for the required processing equipment and the overall system processing techniques to be employed to produce the desired outputs.

The following criteria was established to define incoming waste material (all percentages are by weight):

- Input material contains 25 percent moisture.
- Combustible fraction constitutes 65 percent of all incoming material. Eleven percent of incoming total is reject and 4 percent of fuel fraction is noncombustible. This leaves net combustible material fraction available for fuel product at 54 percent.
- Ferrous fraction constitutes 11 percent. Twenty-five percent of this fraction will be massive ferrous oversized bulky waste; 25 to 50 percent of the ferrous fraction will be beverage cans.
- Glass fraction constitutes 15 percent.
- Mixed nonferrous metals fraction constitutes 1 to 2 percent. Seventy-five percent of this fraction will be aluminum; 10 to 15 percent of the aluminum fraction will be foil products. One-fourth to one-half percent of the total incoming materials will be red metals (copper, zinc).
- Inorganic materials fraction constitutes 7 percent.

System Output

The proposed resource recovery system would process and segregate the following fractions for each 1,000 tons of municipal solid waste with the composition of the incoming raw waste as shown in Table 7-1.

TABLE 7-1

MUNICIPAL SOLID WASTE - BASELINE COMPOSITION FOR EACH 1,000 TONS RECEIVED

	TONS	
Paper	500	
Putrescibles (wet organics)	80	
Plastics	30	
Wood	20	
Fabric, leather, rubber	20	
ORGANICS		650
Ferrous	110	
Nonferrous	20	
Glass	150	
Dirt, rocks, ceramics (misc. inorganics)	70	
INORGANICS		350
TOTAL		1,000 Tons

- Fuel fraction - approximately 544 tons with the following characteristics:
  - Particle size - 3/4-inch nominal with 90 percent (by weight) being 1/2-inch or less.
  - Ash and noncombustible material - 12 to 15 percent (by weight).
  - Moisture content - 25 percent or less (by weight).
  - Heating value - 6,000 Btu per pound.
- Ferrous fraction - approximately 36 tons of massive ferrous and 64 tons of crude ferrous product.
- Glass fraction - approximately 218 tons of crude glass product.
- Mixed nonferrous metals fraction - approximately 138 tons of crude product.

All of the crude fractional outputs are relatively rich in their own major constituent but they also contain other elements which could be extracted. If additional processing equipment were included for each of these fractions, the refinement or upgrading of all the products could be attained.

Transportation

The various transportation and handling modes required for both the receiving of incoming raw waste and the shipment of processed fractions had a definite influence on the processing plant layout and the overall site plan. An effort was made to provide for a smooth flow of truck traffic to, from, and around the processing plant. Placement of the railhaul facilities to one side of the processing plant minimizes the interference and crossovers between most of the local truck traffic and the railhaul servicing units. Waterborne transport was not considered for this conceptual design.

The transportation and handling design criteria, to which the processing plant layout and site plan were addressed, are herein summarized.

A. Incoming Raw Waste

All incoming raw waste to the plant site will be delivered in standard 75 cubic yard, self-ejecting truck trailers or rail cars.

1. Forty percent of this incoming raw waste will arrive by truck transport.

2. Sixty percent of the incoming raw waste will arrive by rail carrier.

B. Shipment of processed fractions

1. Fuel fraction. Total fraction shipped in standard 75 cubic yard self-ejecting truck trailers.

2. Crude ferrous fraction. Shipment of this fraction will be by rail carrier. An alternate, but remote, possibility for shipment of this fraction is truck transport.

3. Massive ferrous fraction. Shipment of this fraction will be by truck transport. An alternate but remote possibility for shipment of this fraction is rail carrier.

4. Crude glass fraction. Shipment of this fraction will be by truck transport; consideration to be given for direct conveyance of processed fraction to a supplemental processing facility in the immediate area of the solid waste processing plant.

5. Crude mixed nonferrous metals fraction. Shipment of this fraction will be by rail. If, in the future, a decision is made to extract the aluminum fraction from this total mix, the aluminum is to be shipped by truck transport.

Assumptions

To provide a conceptual design and cost estimate for a typical municipal solid waste processing installation to be located at a nonspecific site, it was necessary to assume certain basic criteria which, in turn, influenced the dollar cost for the total facility.

- One mile of access highway and one mile of access railroad, with no bridges, will be required.

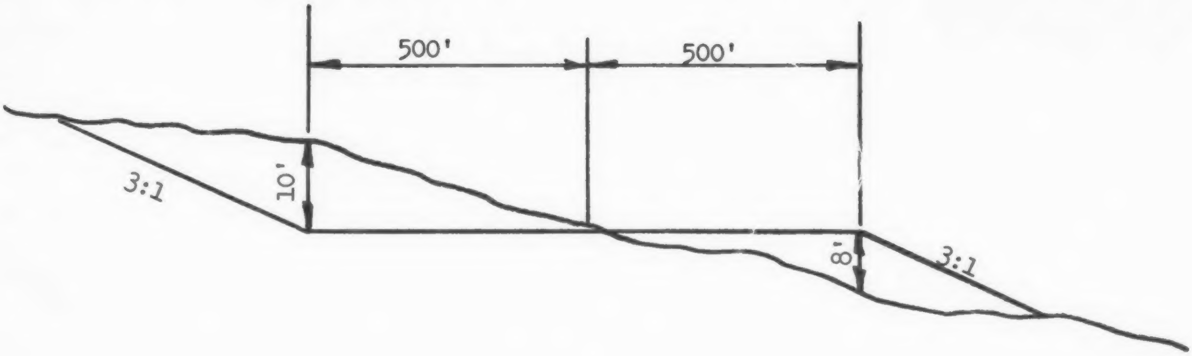
- A yard drainage system with a holding pond will be required.

- For grading: moderate terrain with cut and fill as indicated in Figure 7-3. Assumed 25 percent rock excavation.

- Plant facility will tie into municipally furnished sewer, electrical power supply, and potable water supply.

- Quantity of sewage produced in process plant is small. All wash down water goes to clarifier; sludge from clarifier to landfill--overflow to sewage.

FIGURE 7-3


500'
500'
3:1
10'
8'
3:1

TYPICAL GRADING SECTION

- Soil bearing pressure for foundations = 2,000 pounds/sq. ft.
- 300 sq. ft. of trenches with grating required.
- Designed for all support steel, including conveyor trusses, to be done inhouse.
- The intraplant communication system will employ a combination of two-channel personal portable radios and an intercom; offsite or future interplant communications will use public telephones and leased lines.

PLANT DESIGN

Raw Refuse Receiving

The raw refuse receiving pit occupies one entire end of the processing plant. This pit measures 170 feet long by 190 feet wide by 14 feet deep and has been sized to provide temporary storage for 2,000 tons of incoming raw waste at an average density of 300 pounds

An overhanging roof structure shelters the pit and maintains a minimum 25 feet of clearance for vehicular traffic. The pit is generally open on three sides to accommodate a minimum of twelve 75 CU-YD self-ejecting trailers which transport the raw refuse to the facility.

Storage areas for segregated oversized bulky waste (OBW) are provided adjacent to a ramp that permits pit access for a pair of rubber-tracked crawlers.

Waste received by rail would be transported from the rotary dumper to the receiving pit by conveyor.

The crawlers working in the pit serve a triple purpose.

A. Their primary function is to keep both apron conveyors, located on each side of the pit, loaded with raw waste.

B. In the performance of their primary function, the movement of these vehicles over the top of the raw waste pile tends to break up and further loosen and precondition the compacted wastes prior to loading on the apron conveyors.

C. Segregation and temporary storage of the OBW is provided by these crawlers.

Unit Process Design Considerations - Equipment Specifications

The data and information outlined in the preceding sections that describe the municipal solid waste input and desired output of the processing plant form the basis for the design of individual system equipment, including its selection and performance characteristics.

This basis begins with a conceptual flowsheet (Figure 7-4). From this flowsheet, a material balance sheet (Figure 7-5) is developed from the input waste composition. It is this information that is used to determine equipment capacities, energy requirements, and product recovery efficiencies.

The following text is a description of each unit operation within the processing plant. Each description provides the performance requirements for that particular equipment with regard to both its input feed and desired output characteristics.

Bradford Breaker--The Bradford Breaker is a heavy-duty trommel capable of processing massive objects and has a nominal throughput of 75 tons per hour.

The Bradford Breaker selected for this application is 15 feet in diameter by 40 feet long and revolves in a roller mounted frame at a speed of 12 to 18 RPM The cylindrical portion is installed on a 7 degree slope to the horizontal and accepts the incoming municipal solid waste at its elevated end.

The deposited refuse is raised within the breaker by radial lifting shelves attached to the inner surface of the revolving perforated plate. The performations in the plate are 4-3/4 inches in diameter and are sized to pass the majority of the inorganic content present in the refuse. As the lifting plates raise the refuse, the material falls, by gravity, back to the heavy plate structure. Friable inorganics, which constitute 22 percent of the incoming refuse, are broken during this tumbling action throughout the length of the trommel. Concurrently this tumbling action opens plastic bags containing other inorganics and exposes them to the screen openings.

An excess of 90 percent of the friable inorganics are passed through the plate perforations during this tumbling action which provides sufficient residence time for the entering refuse to:

1. Expose the fine and small inorganics to the holes.
2. Break and expose the larger friable inorganics to the holes.
3. Liberate small and large inorganics from paper and plastic containers and subsequently expose and break these inorganics so they will pass through the holes.

The resulting minus 4-3/4-inch product is rich in inorganics but also contains significant quantities of small organic material such as paper and high moisture content putrescible matter (food wastes).

FIGURE 7-4
CONCEPTUAL FLOW DIAGRAM

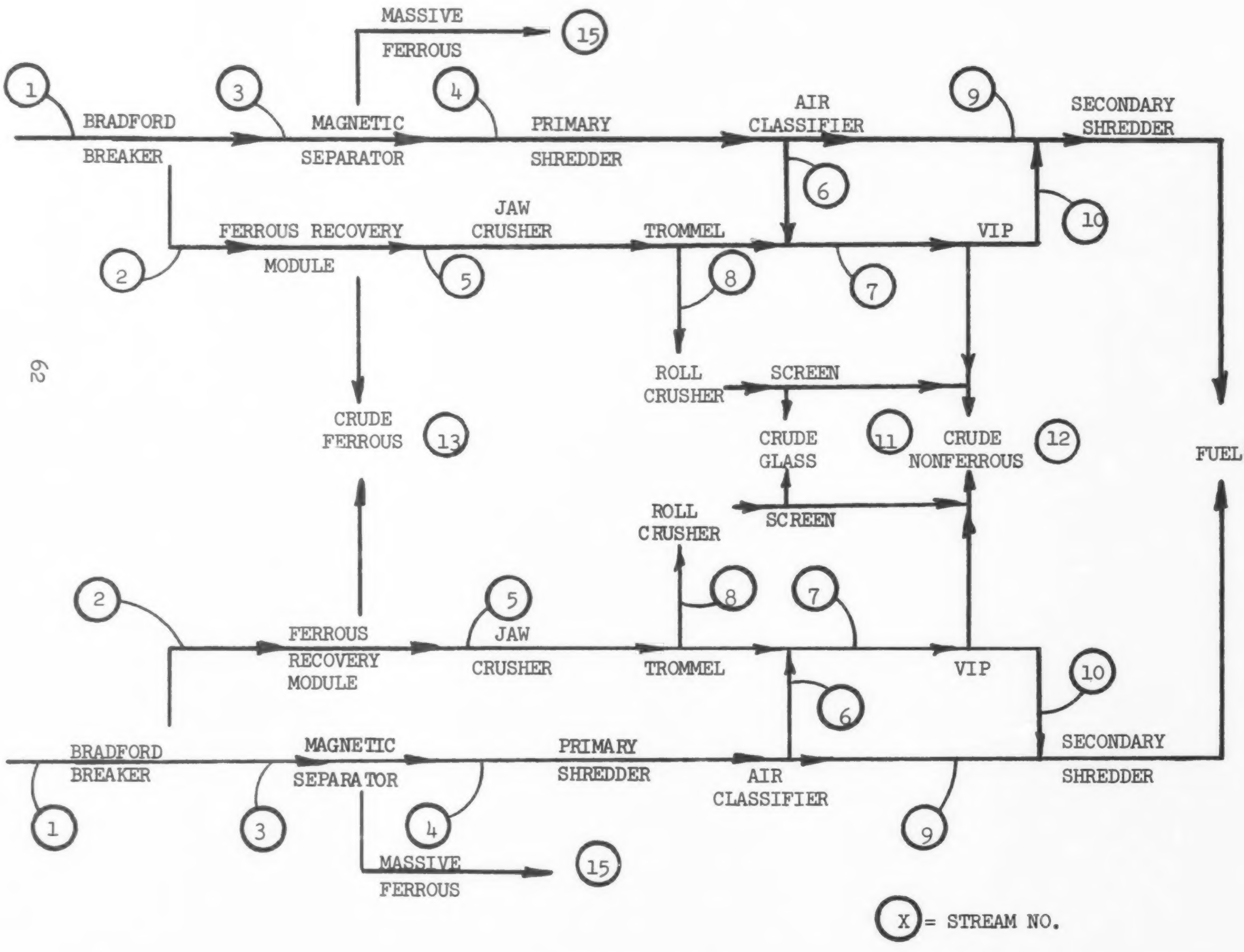

MASSIVE FERROUS
15
1
BRADFORD BREAKER
3
MAGNETIC SEPARATOR
4
PRIMARY SHREDDER
AIR CLASSIFIER
9
SECONDARY SHREDDER
6
10
2
FERROUS RECOVERY MODULE
5
JAW CRUSHER
TROMMEL
8
7
VIP
ROLL CRUSHER
SCREEN
CRUDE FERROUS
13
CRUDE GLASS
11
CRUDE NONFERROUS
12
FUEL
14
ROLL CRUSHER
SCREEN
2
FERROUS RECOVERY MODULE
5
JAW CRUSHER
8
TROMMEL
7
VIP
10
6
SECONDARY SHREDDER
1
BRADFORD BREAKER
3
MAGNETIC SEPARATOR
4
PRIMARY SHREDDER
AIR CLASSIFIER
9
MASSIVE FERROUS
15
X = STREAM NO.

FIGURE 7-5

MATERIAL BALANCE

TONS PER 1000 TONS RECEIVED

STREAM NUMBER
(See Figure 7-4 for diagram in which these streams are identified)

	1	2	3	4	5	6	7	8	9	10	11	12	13*	14	15
Paper	250	25	225	225	24	5	11	13	220	11	6	30	2	462	-
Putrescibles	40	36	4	4	36	3	4	32	1	2	34	40	-	6	-
Plastics	15	3	12	12	3	1	2	1	11	1	1	5	-	24	-
Wood	10	5	5	5	5	3	1	4	2	3	1	9	-	10	-
Fabric, Leather, Rubber	10	1	9	9	1	4	1	-	5	2	-	6	-	14	-
Ferrous	55	35	20	2	3	2	2	1	-	1	1	7	64	2	36
Nonferrous	10	7	3	3	7	2	5	2	1	2	1	13	-	6	-
Glass	75	70	5	5	70	2	7	63	3	3	122	16	-	12	-
Dirt, Rocks, Ceramics . .	35	30	5	5	30	3	3	27	2	1	52	12	-	6	-
Tons/8 hr. Shift**	500	212	288	270	179	25	36	143	245	26	218	138	66	542	36
Lbs /ft.^{3}	11	15	7	7	15	15	20	25	7	7	90	69	12	5	12

* Line 13 represents the output of the ferrous recovery modules which recover 64 tons of ferrous and recycle 2 tons of paper to the secondary shredders.

** Lines 1 through 10 represent tons per process line (500 tons each).
Lines 11 through 15 represent the sum total of product recovered from both process lines (1000 tons).

The organic rich plus 4-3/4-inch product is discharged at the low end of the breaker and contains large ferrous and nonferrous metals as well as large nonfriable inorganics such as rocks and bricks.

The Bradford Breaker unit operation prior to shredding offers several processing advantages.

1. The throughput capacity of the primary shredder is reduced and consequently the horsepower requirement of the shredder is reduced.

2. The small minus 4-3/4-inch inorganic fraction removed from the primary shredder feed reduces the abrasive wear on the shredder hammers and grates.

3. The inorganic rich fraction contains glass and can stock, both aluminum and ferrous, in a more readily recoverable form than that produced as a primary shredded, air classified heavy product.

Magnetic Separator and Ferrous Recovery Module--Both the large and small sized fractions discharged by the Bradford Breaker are conveyed to separate ferrous recovery units.

The plus 4-3/4-inch organic rich fraction contains large or massive ferrous objects and it is passed over an electromagnetic separator which removes the ferrous product from the stream. This ferrous product is then conveyed directly to either a railcar or truck for loading and shipment. The remainder of the stream continues for further processing.

The minus 4-3/4-inch inorganic rich fraction contains the small tramp iron and tin can stock and it is conveyed to a ferrous recovery module. This ferrous recovery module utilizes an electromagnet for removal of the ferrous material from the stream and incorporates a pneumatic cleaning device to remove loose contaminants. These loose contaminants contain a significant amount of usable fuel (approximately 3 percent of the input stream) and this is pneumatically conveyed downstream where it is air classified and reintroduced to the fuel flow stream immediately ahead of the secondary shredder. The recovered ferrous product is conveyed to railcar or truck for loading and shipment. The remainder of the stream continues for further processing.

Fuel Processing Equipment--Primary Shredder

The plus 3-3/4-inch fraction, after ferrous removal, contains the majority of the combustible fuel present in the incoming plant solid waste. This organic rich fraction contains some large unacceptable components which must be removed in order to provide an acceptable fuel product.

The primary shredder processes this material and produces a more uniformly sized minus 6-inch fraction which subsequently can be more easily air classified on the basis of density separation. In addition, the primary shredding operation is the initial size reduction process to convert the organic combustibles to the size specification required for the power plant fuel product.

Air Classifier

The discharge from the primary shredder is conveyed to the air classifier. This provides separation and removal of heavy inorganic and organic materials from the crude primary shredded fuel fraction. The air classifier separates material based on size, shape, and density by subjecting the refuse to a continuous flow of air in the air classifier chamber. The dense inorganics and organics, whose terminal velocity exceeds the velocity of the air stream in the chamber, are separated from the lighter organic materials.

The lighter fraction is pneumatically conveyed from the air classifier to a cyclone where entrained solids are removed from the conveying air medium prior to processing through the secondary shredder.

The heavy material removed from the light fraction consists of inorganics such as nonferrous metal alloys and other organics composed of leather, plastic bottles, and rubber which cannot meet the fuel size specification in addition to possessing unacceptable burning characteristics. This heavy material is further processed to concentrate and reclaim the contained metal alloys.

Secondary Shredder

The paramount performance requirement of the secondary shredder is to reduce the size of the air classified crude fuel product from minus 6 inches to a nominal 3/4-inch product that is 90 percent (by weight) 1/2-inch or less.

The output of the secondary shredder is pneumatically conveyed through a cyclone before being belt conveyed to compaction equipment for outloading and transport to the power plant as a fuel.

Inorganic Materials Processing Equipment--Jaw Crusher

The minus 4-3/4-inch inorganic rich stream discharged from the Bradford Breaker and the ferrous recovery module is conveyed to a jaw crusher to size reduce this material and prepare it for processing in other downstream separation equipment.

The jaw crusher is designed to effectively handle abrasive materials such as those found in the inorganic rich fraction with a minimum of machine wear. The jaw crusher operates on a pressure principle and is effective in this step of the process by taking advantage of the friable nature of the glass and the malleable nature of the metals concentrated in the stream entering the equipment. Furthermore, the jaw crusher does not overgrind the friable material thus keeping the fines to a minimum.

The friable inorganics are reduced in size from minus 4-3/4-inch to a minus 3/4-inch product with a narrow size range. The malleable metals and organic materials, due to their physical properties, are not appreciably reduced in size although the metals become somewhat flattened.

Trommel Screen

The jaw crusher product is conveyed to a trommel screen containing 3/4-inch openings for size separation. This screening operation--much the same as that of the Bradford Breaker--produces two fractions; a minus 3/4-inch glass rich fraction and a plus 3/4-inch organic rich fraction.

The minus 3/4-inch glass rich fraction also contains small nonferrous and nonmagnetic metals, such as copper, stainless steel, and other alloys. The plus 3/4-inch organic rich fraction contains some acceptable combustible material and aluminum can stock.

VIP (Vibratory Impact Parts Separator)

The plus 3/4-inch product from the trommel screen and the heavy material from the air classifier are conveyed to and processed in the VIP, which is a secondary air classifier, designed to recover the intermediately sized acceptable fuel product and concentrate the aluminum can stock with the large nonferrous metals.

The air classification principle of operation is similar to that used in the air classification of the primary shredded crude fuel product, but the size and capacity of this unit is greatly reduced. The light product resulting from the VIP processing is conveyed to the secondary shredder for final size reduction. The heavy product constitutes a crude aluminum fraction that is also rich in nonferrous metals and is conveyed to an outloading point for shipment by rail or truck to the metals reclaiming market.

Roll Crusher

The minus 3/4-inch trommel screen output is conveyed to a roll crusher or sand mill machine. Adjustable dual rollers process the friable organics and small nonferrous fraction utilizing the same principle as the jaw crusher. The roll crusher reduces the friable inorganic glass fraction to pass a minus 10 mesh and at the same time flattens the metal which tends to increase its size.

Screen

The roll crusher product is conveyed to and processed by a 10 mesh horizontal vibrating screen which separates the fine glass from the larger, flattened nonferrous metals. Both these products from the screen are contaminated and hence crude in nature.

Each of these products is conveyed separately to an outloading station for shipment. The nonferrous fraction is sold to the market and the glass fraction is sent to landfill.

Process Control Description

The solid waste processing plant incorporates a number of independent and self-contained items of equipment which must operate as an integrated system. The design concept for the processing plant control is to coordinate this total system.

For the successful operation of the processing plant, the process and operational control will:

A. Provide for sequential starting and stopping for normal operation by control switches for each individual equipment or by selecting and initiating automatic sequential starting or stopping by means of a programmable controller.

B. Prevent overload conditions to critical equipment and provide for the sequential shutdown of the process line(s) in the event of equipment malfunction or failure.

Normal processing and operational control of each process line will be exercised from its own central control room located inside the processing portion of the plant. Each control room will have a master control console to house the integrated processing and operational control logic, all the necessary switches, overrides, displays, alarms, annunciators, and other related items to permit "single point" process line control.

These central control rooms will provide overall control and communication for their respective process lines. Additionally, they will provide for transfer to "local" control to each of the various machines and equipment for test purposes and adjustments. Activation of this transfer function will allow the selected machine's process line master switch located in the master control console to be bypassed except under emergency stop conditions. The "local" control remains in effect until the transfer function is deactivated.

"Local" control provides for start-stop at the selected equipment or machine. The "local" stop switches located at this machinery incorporate a keylock feature to prevent inadvertent startup during adjustment, servicing, or maintenance.

This control philosophy provides only one start location for any equipment or machine at any given time.

Trip lines are provided along all process line conveyors to effect emergency stops by floor personnel. If these trip lines are actuated, a manual restart is required.

Portions of the process lines, which must be monitored at their respective central control rooms, but cannot be observed physically, are to be monitored by television with viewing screens and remotely controlled cameras. Each process line will incorporate four cameras placed to monitor the plus 4-3/4-inch discharge of the Bradford Breaker, the primary shredder and its feed, the secondary shredder, and the fuel outloading stations.

1. Sequential starting and stopping for normal operation.

   For normal startup of each process line, activation of the machines, equipment, and conveyors is sequenced beginning at the output or discharge ends of the lines. Normal stopping of either process line is accomplished in the reverse sequence of startup--i.e. begin shutdown at the input ends of the process line. The process flow diagram defines the machinery, equipment, and conveyor sequence.

2. Prevention of overload conditions to critical equipment and sequential shutdown of process lines due to equipment malfunction or failure.

   An automatic hold condition and interlock is provided which causes selected upstream conveyors to stop in the event of individual equipments experiencing either a malfunction or a sustained overload condition in excess of a predetermined time. Each automatic hold condition is alarmed at the master control console. This hold may be initiated as a result of normal metering functions of feeding equipment or overload sensors on the shredders, air classifiers, ferrous recovery modules, or jaw crushers.

Stopping selected conveyors will prevent an unmanageable pileup of in-process materials at the affected equipment and will also permit other related in-line equipment to purge or discharge themselves of in-process materials. If these items of equipment subsequentially must be shutdown due to this hold, they will be able to restart under no load conditions.

The hold condition is automatically released when the overload condition is corrected by the continued effort of the monitored equipment after the feed conveyors have stopped.

Failure of a hold condition to be released within the prescribed interval of time will activate a stop condition for all the upstream processing equipment for which restart must be accomplished manually.

The frequency of restarts which cause thermal conditions to exceed the motor operating parameters are alarmed separately to the master control consoles and restarts must be accomplished manually if these alarms are triggered.

The hoppers which accept the processed fuel fraction for temporary storage before compaction and shipment incorporate bin indicating devices. Generation of alarm signals and a means to shut down the process line(s) if the hoppers overfill are integrated in the process and operational control system.

Auxiliary Plant Facilities

A. Office - Visitors Building

A three-level structure separate from, but connected to, the processing plant accommodates general office space for plant personnel and public visitors to the facility.

1. A lobby and reception area occupy the ground level. An elevator is provided for access to the upper levels which serves as a vehicle to accommodate either inplant personnel or public handicapped.

2. General office space for the plant superintendent, assistant superintendent, secretary, and files is provided on the second level. A covered walkway on bridge at this level allows access to the processing plant.

3. The third level contains restrooms plus an observation window for the visitors to view some of the yard operation. Another covered walkway or bridge to the processing plant, at this level, allows the public visitors access to a fully glassed observation deck spanning the entire width of the processing plant for witnessing the waste processes.

B. Service and Personnel Area

A two-level area containing approximately 6,700 square feet is centrally located between the fuel fraction outloading equipment of each process line. The lower level provides space for general plant maintenance work, a machine shop, electrical and small parts storage, and vehicular servicing of a minor nature. Inplant personnel accommodations and facilities are contained on the upper level; these include lockers, restroom, shower, vending machines, and a lunch room.

C. Yard Facilities

1. Weigh-in and weigh-out of truck transport trailers is provided by scales embedded in the entrance/exit roadway at the facility. Similar data is provided for the rail-haul transport by a weigh-in-motion scale installed with the yard trackage. A scale office is located adjacent to the truck scales and houses the equipment, for both truck and rail scales, which provides automatic printout data for record purposes.

2. Fuel oil and gasoline storage has been provided in the yard for routine refueling of the site controlled vehicles. These include the pit crawlers, yard tractors, trackmobile, and the side porters.

Environmental Design Considerations

The processing plant and facility will comply with all the environmental restrictions pertaining to air, water, land, noise, and odor pollution during and after construction. The inclusion of these environmental control systems increase the cost of ownership and operation of the processing plant and facility, but are mandatory under present regulations.

Safety Systems Description

A. Fire Protection

Fire control throughout the plant and facility will be provided by automatic dry-type sprinkler system, water spray system, fire hose racks, or any combination of these depending upon location.

Fire hydrants will be located throughout the yard.

B. Ventilation and Dust Control

The bulk of the process plant ventilation air will be drawn from the receiving pit area and passed through the baghouse filters before discharging to the atmosphere.

Specific locations for dust control along each process line have been defined on the process flow diagram. A network of pneumatic ducts will transport the collected dust to the baghouse filters where it will be filtered out and loaded on truck transport for final disposal to landfill.

If it becomes necessary to provide dust control in the receiving pit area after the operation of the plant has commenced, water sprays can be integrated to the receiving area water headers.

C. Explosion and Fire Suppressants

The makeup of incoming municipal solid waste to a processing plant has been statistically proven to contain potentially hazardous elements which will explode during processing. One explosion is normally experienced for approximately every one hundred thousand tons of waste processed. These elements include such items as gunpowder, propane bottles, and partially filled containers of paint thinners and gasoline.

The location of explosion and fire suppressant equipment has been defined for each processing line and is shown on the process flow diagram. For all cases, each installation is a separately engineered design for the designated equipment; every installation is unique.

A capsule review of an explosion suppressant installation is given here. After ignition of an explosive mixture, there is a short time delay (up to 10 milliseconds) as a flame front is established and as it commences its radial propagation. If combustion progresses unchecked, the high temperatures within the flame front create gaseous expansion. This, in turn, results in a pressure buildup that ultimately grows until destructive pressures are achieved.

Strategically placed radiation and/or pressure sensitive detectors within the system sense ignition of the material and simultaneously actuate suppressive measures. In less than 5 milliseconds, these detectors trigger high speed control devices to arrest the explosion before it reaches destructive force.

The following methods of control will be integrated to these devices where practical.

- Discharge suppressants to halt combustion.
- Open vents in advance of pressure buildup
- Provide immediate shutdown of affected process machinery.
- Sound alarms.
- Initiate additional protective devices such as CO_2, sprinkler systems, or water spray systems.

Availability of Equipment

Based on information obtained from equipment suppliers by both TVA and the personal services consultant (Black, Crow, and Eidsness), the current maximum delivery time for any of the required facility equipment or materials is 18 months from date of order. However, due to the cyclical nature of the industry, delivery schedules can change with the general economy, becoming longer as capital expenditure activity increases.

Personnel Requirements

It is contemplated that this facility will operate and process municipal solid waste on a two-shift basis for a total of 16 hours per day--5 days per week schedule. This schedule will increase to 7 days per week if minimum storage only is provided at Bull Run. A third shift is required to perform routine maintenance and service on the plant process equipment.

For the first 8-hour shift (regular), the estimated staff requirements are:

	Rail Receiving Using Piggyback Trailers
(1)	Superintendent
(1)	Secretary
(1)	Operating Foreman
(1)	Maintenance Foreman
(2)	Overall Controllers
(3)	Trailer Handlers
(4)	Operator-Observers
(2)	Pit Crawler Operators
(4)	Maintenance Men
(1)	Scale Man
20	TOTAL

	Rail Receiving Using Car Dumper
(1)	Superintendent
(1)	Secretary
(1)	Operating Foreman
(1)	Maintenance Foreman
(4)	Car Cover Handlers
(2)	Switch Engine Operators
(1)	Car Dumper Operator
(5)	Operator-Observers
(2)	Pit Crawler Operators
(4)	Maintenance Men
(1)	Scale Man
25	TOTAL

For the second 8-hour shift (regular), the estimated staff requirements are:

	Rail Receiving Using Piggyback Trailers
(1)	Assistant Superintendent
(1)	Operating Foreman
(1)	Maintenance Foreman
(2)	Overall Controllers
(3)	Trailer Handlers
(4)	Operator-Observers
(2)	Pit Crawler Operators
(4)	Maintenance Men
(1)	Scale Man
19	TOTAL

	Rail Receiving Using Car Dumper
(1)	Assistant Superintendent
(1)	Operating Foreman
(1)	Maintenance Foreman
(2)	Overall Controller
(4)	Car Cover Handlers
(2)	Switch Engine Operators
(1)	Car Dumper Operator
(5)	Operator-Observers
(2)	Pit Crawler Operators
(4)	Maintenance Men
(1)	Scale Man
24	TOTAL

For the third 8-hour shift (maintenance), the estimated staff requirements are:

Rail Receiving Using Piggyback Trailers		Rail Receiving Using Car Dumper	
(1)	Maintenance Foreman	(1)	Maintenance Foreman
(14)	Maintenance Men	(15)	Maintenance Men
15	TOTAL	16	TOTAL

COST ESTIMATES

A. Capital Costs

1. TVA estimate for a 2000 TPD processing plant (1977 dollars) with no railroad facilities

	Amount ($ 000)
Land and Land Rights	$ 310
Access Highway and Railroads for Permanent Use	1,080
General Preparation of Site	130
Structures	7,365
Processing Equipment	6,875
Cranes and Hoisting Equipment	85
Mobile Equipment	985
Miscellaneous Items	390
Electrical Work	2,910
Subtotal	21,555
Construction Facilities	2,155
Total Direct Construction	23,710
Field General Expense	2,370
Contingency	4,940
Total Field Construction	31,020
Engineering Design	995
Manager's Office - OEDC	95
CSB - Engineering Group	25
Personnel	40
Purchasing	120
Medical Services	60
Employee Compensation Benefits	350
A & G	325
Interest During Construction	1,970
Total Project (accuracy ± 30%)	$ 35,000*

*This cost does not include the cost of a car dumper.

Note: The direct cost of processing equipment is estimated at $6,875,000. All other estimates would vary substantially depending on (1) the rail and highway requirements of the site; (2) the type of building selected to house the equipment; (3) the type of electrical and environmental control system selected; and (4) local labor rates and field construction costs. All of the listed elements must be considered in developing an accurate capital cost estimate.

2. Black, Crow, and Eidsness estimate for a 2000 TPD processing plant (1975 dollars with total escalated to 1977 dollars) with no rail facilities

	Amount ($ 000)
Site Work	$ 1,685
Scale Office	88
Office and Visitor Building	344
Receiving and Processing Building	5,619
Process Equipment	9,463
Plumbing	19
Drainage System	172
HVAC Systems	83
Fire Protection	146
Communications	17
Control	68
Electrical	2,543
Fuel Oil and Gas Storage	25
Subtotal	20,272
Contingency	4,055
Construction Cost	24,327
Engineering Design	1,152
Landscaping	10
Procurement Costs for:	
Communications, Control and Electrical Process	101
Site Work, Building Work, and Process Equipment	271
Land costs for:	
Access Roadway and Railroad	40
Costs for:	
Resident Engineering and Construction Services	560
Total	26,461
Escalated to 1977 dollars (accuracy ± 30%)	31,935
Interest during Construction	1,915
Total Project (accuracy ± 30%)	$ 33,850*

*This cost does not include car dumpers.

3. TVA cost estimate for a 2000 TPD processing plant (1977 dollars) including railroad car dumping facilities at the processing plant but with no railroad bridge or access railroad.

	Amount ($ 000)
Land and Land Rights	$ 680
General Yard Improvements	1,260
Receiving and Process Building, Office Wing, and Scale House	7,365
Car Cumping & Receiving Facilities	1,660
Processing Equipment	6,875
Cranes and Hoisting Equipment	85
Mobile Equipment	725
Miscellaneous Items	390
Electrical Work	3,130
Subtotal	22,170
Construction Facilities	2,230
Total Direct Construction	24,400
Field General Expense	2,440
Contingency	4,830
Total Field Construction	31,670
Engineering Design	1,250
Manager's Office - OEDC	100
CSB - Engineering Group	25
Personnel	45
Purchasing	130
Medical Services	60
Employee Compensation Benefits	350
A&G	340
Interest During Construction	2,030
Total Project (accuracy ± 30%	$ 36,000

4. TVA cost estimate for a 2000 TPD processing plant (1977 dollars). Estimate includes complete railroad car dumping facilities complete with bridge and access railroad.

	Amount ($ 000)
Land and Land Rights	$ 310
Access Highway and Railroads for Permanent Use	1,080
General Preparation of Site	130
General Yard Improvements	1,825
Receiving and Process Building, Office Wing, and Scale House	7,365
Car Dumping & Receiving Facilities	1,660
Processing Equipment	6,875
Cranes and Hoisting Equipment	85
Mobile Equipment	725
Miscellaneous Items	390
Electrical Work	3,130
Subtotal	23,575
Construction Facilities	2,365
Total Direct Construction	25,940
Field General Expense	2,600
Contingency	4,910
Total Field Construction	33,450
Engineering Design	1,310
Manager's Office - OEDC	110
CSB - Engineering Group	25
Personnel	45
Purchasing	130
Medical Services	60
Employee Compensation Benefits	350
A&G	360
Interest During Construction	2,160
Total Project (accuracy ± 30%)	$ 38,000

1/ Reference unmarked Heavy Equipment Design study drawing Nos. 1-5 and 2A; process flow diagram R-3 dated May 8, 1975; and Architectural Design study drawing Nos. 1-8, dated May 29, 1975, revised June 10, 1975. Based on construction start January 1, 1977, with completion in July 1978. Estimate is revised to provide the facilities unloading refuse by rotary railroad car dumper.

5. A cost estimate for a 2800 TPD processing plant with complete railroad car dumping service was derived as follows:

$$\frac{(2800\ \text{TPD})}{(2000\ \text{TPD})}\ (\$38{,}000{,}000) = \$53{,}200{,}000$$

This figure was rounded to $54 million and was used in figures 14-1,-2, and -3 for the processing plant capital costs.

6. TVA estimate of a 3850 TPD processing plant for use with the gasification and methanation process. This processing plant cost estimate includes complete railroad car dumping facilities.

	Amount ($ 000)
General Yard Improvements	$ 1,275
Structures	
Excavation and Backfill	825
Concrete	4,300
Structural Steel	3,060
Architectural Work	3,270
Service Work	820
	12,275
Processing Equipment	11,230
Rail Car Dumping and Receiving Facilities	2,690
Cranes and Hoisting Equipment	175
Mobile Equipment	790
Miscellaneous Items	580
Electrical Work	5,500
Subtotal	34,515
Construction Facilities	3,455
Total Direct Construction	37,970
Field General Expense	3,800
Contingency	7,590
Total Field Construction	49,360
Engineering Design	1,450
Manager's Office - OEDC	160
CSB - Engineering Group	40
Personnel	60
Purchasing	160
Medical Services	100
Finance	95
A&G	425
Interest During Construction	4,150
Total Project (accuracy ± 30%)	$ 56,000[a]

a. Based on 1977 prices with a two year construction period.

7. TVA estimate of a syngas - methanol production plant

		Amount ($000's)
Basic Syngas Plant		
Equipment, Buildings, Etc.	$	38,000
Spare Parts		890
		38,890
Pumping Station		
Equipment and Structure		2,700
Spare Parts		110
		2,810
Methanol Plant		
Equipment, Buildings, Etc.		16,670
Spare Parts		660
		17,330
Total Construction Cost		59,030
Engineering Design		2,300
Manager's Office - OEDC		260
CSB - Engineering Group		80
Personnel		100
Purchasing		200
Medical Services		150
Employee Compensation Benefits		850
Finance		160
A&G		730
Contingency Allowance		9,140
Interest During Construction		7,000
Total Project Cost (1974 prices)	$	80,000
Total Project Cost (1977 prices)	$	105,000

Total construction costs as developed by Ralph M. Parsons Company for a plant size of 3,848 tons production per day of MSW. TVA costs are added including general expense, contingency, and interest during construction.

8. TVA cost estimates of transfer stations.

a. These costs were used in computing transfer station capital costs in Figures 14-1 through 14-12.

	($000's)		
Capacity per 8-hour day	1600-tons	1200-tons	800-tons
Land and Land Rights	$ 95	$ 95	$ 95
General Yard Improvements			
Plant Tracks	635	540	385
Other	120	90	60
Transfer Structure	1,065	830	610
Scale, Office, & Employee Bldg	120	120	120
Car Uncovering & Covering Sta., Including Cranes	110	110	110
Truck Scales	30	30	30
Fuel Oil and Gas Storage	160	155	150
Mobile Equipment	670	590	425
Electrical Work	250	230	200
Subtotal	3,270	2,805	2,200
Construction Facilities	330	285	220
Total Direct Construction	3,600	3,090	2,420
Field General Expense	360	310	245
Contingency	735	625	530
Total Field Construction	4,695	4,025	3,195
Engineering Design	140	140	120
Manager's Office - OEDC	15	15	10
CSB - Engineering Group	10	10	10
Personnel	10	10	10
Purchasing	20	20	20
Medical Services	10	10	10
Employee Compensation Benefits	50	50	50
A&G	50	45	35
Interest During Construction	200	175	140
Total Project	$ 5,200[a]	$ 4,500[a]	$ 3,600[a]

a. Based on construction during CY 1977.

b. Operating costs per month (1977 dollars)
5 day-week, 2 eight-hour operating shifts/day

	Amount ($ 000)	
	Rail Receiving Using Piggyback Trailers	Rail Receiving Using Car Dumper
Manpower Requirements	$ 104	$ 119
Energy Requirements	38	39
Materials and Supplies	44 to 64	45 to 65
Total Range	$ 186 to 206	$ 203 to 223

SECTION VIII

PRODUCT MARKETING

A basic parameter for TVA's regional resource recovery study was that revenues from recoverable products must offset project costs in cases where the revenues are not sufficient to offset these costs,a dump fee will be necessary. No power system revenues were to be used to subsidize the project. The revenue potential therefore had to be tied down with signed contracts before final project evaluation could be made. Marketable products other than fuel to be derived from the region's solid waste stream included:

1. Ferrous metals product
2. A nonferrous metals product
3. A mixed color glass product

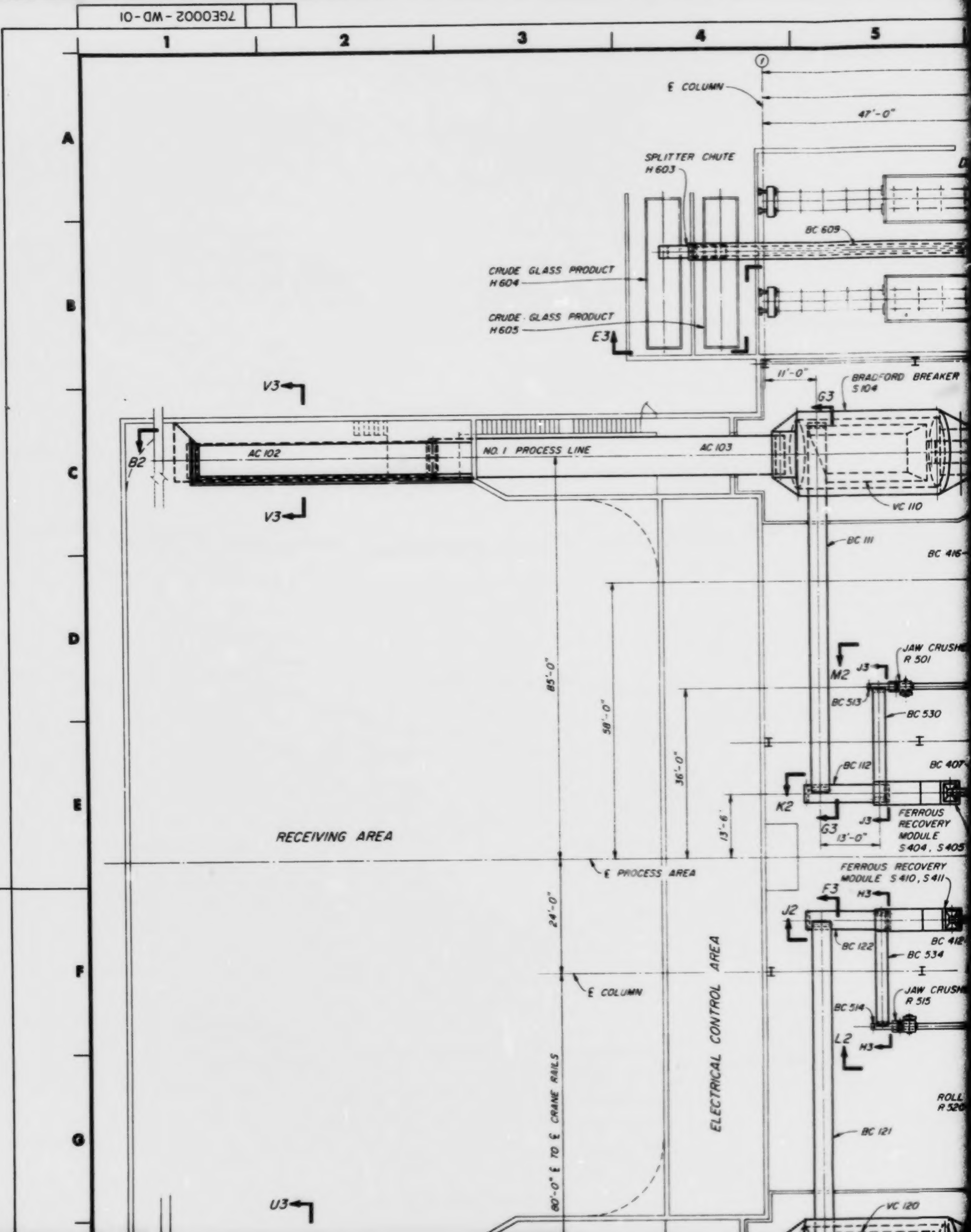
To establish some degree of confidence in the revenue picture for metals and glass, an invitation to bid on the recoverable products was developed and issued to industries. In this invitation to bid, firm bids were requested for 5- and 10-year contract periods. The bid document which thoroughly described the marketing approach for products from a Knoxville 14,000-ton-per-week processing facility is attached hereto.

Most of the bids were tied to a floating index. To predict what future price levels will be for the recoverable products was extremely difficult if not impossible. Looking back at past trends to make a projection was not a valid approach. The energy crisis more or less cleaned the slate. To keep the economic evaluation on an equal basis with project cost estimates, revenues used were those predicted for 1979. Beyond 1979, it was assumed that costs and revenues would increase proportionately. Bids on the recovered products were opened on September 3, 1975. With this bid data in hand and using the fuel product value set by TVA, revenues were determined as follows:

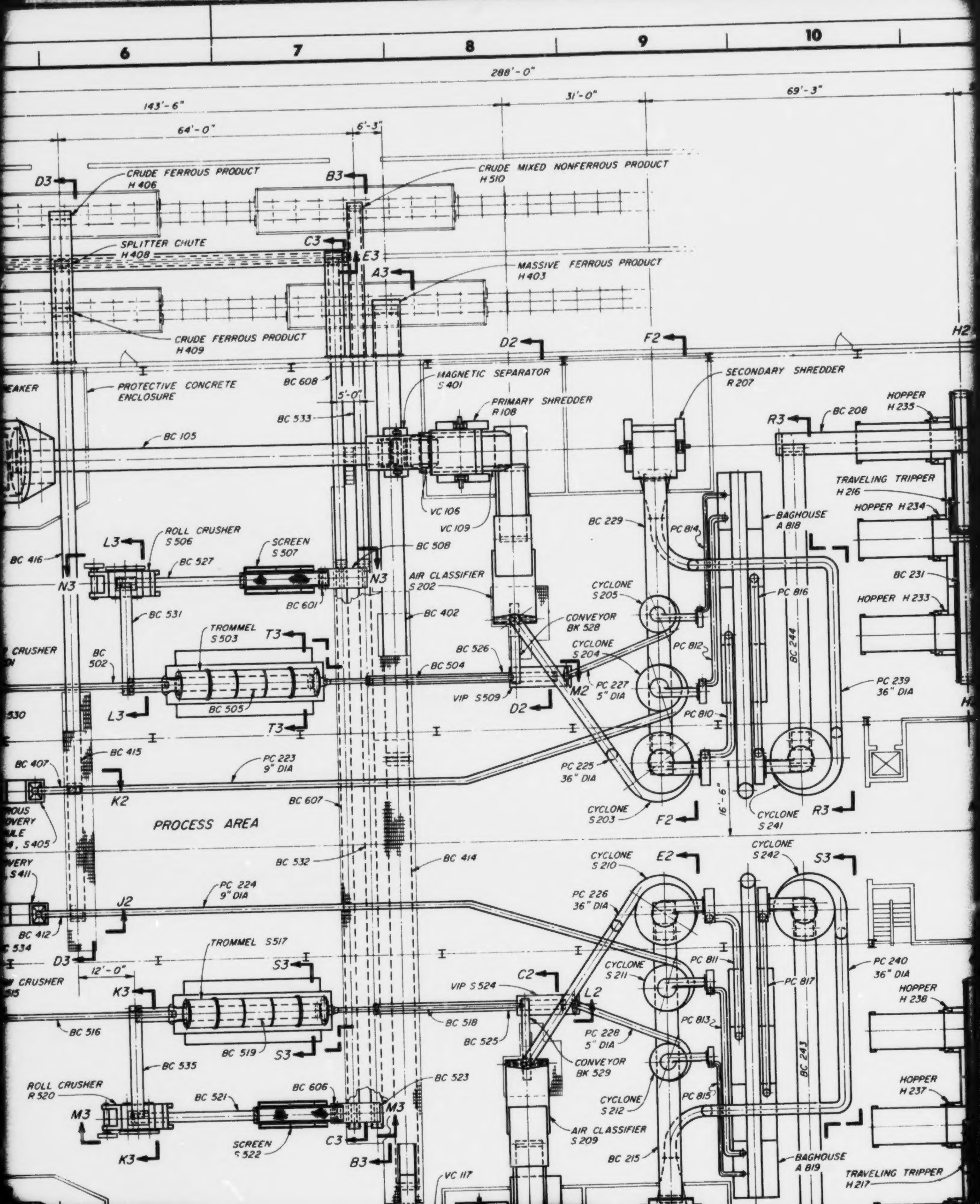
Ferrous Metals - Bid data indicated that ferrous metals could be marketed f.o.b. TVA's processing plant at 50 percent of the No. 1 dealer bundle scrap price. Based on industry forecast, the price of No. 1 dealer bundles in 1979 would be $90.

Approximately 10 percent of the waste processed would be recovered as a ferrous metals product.

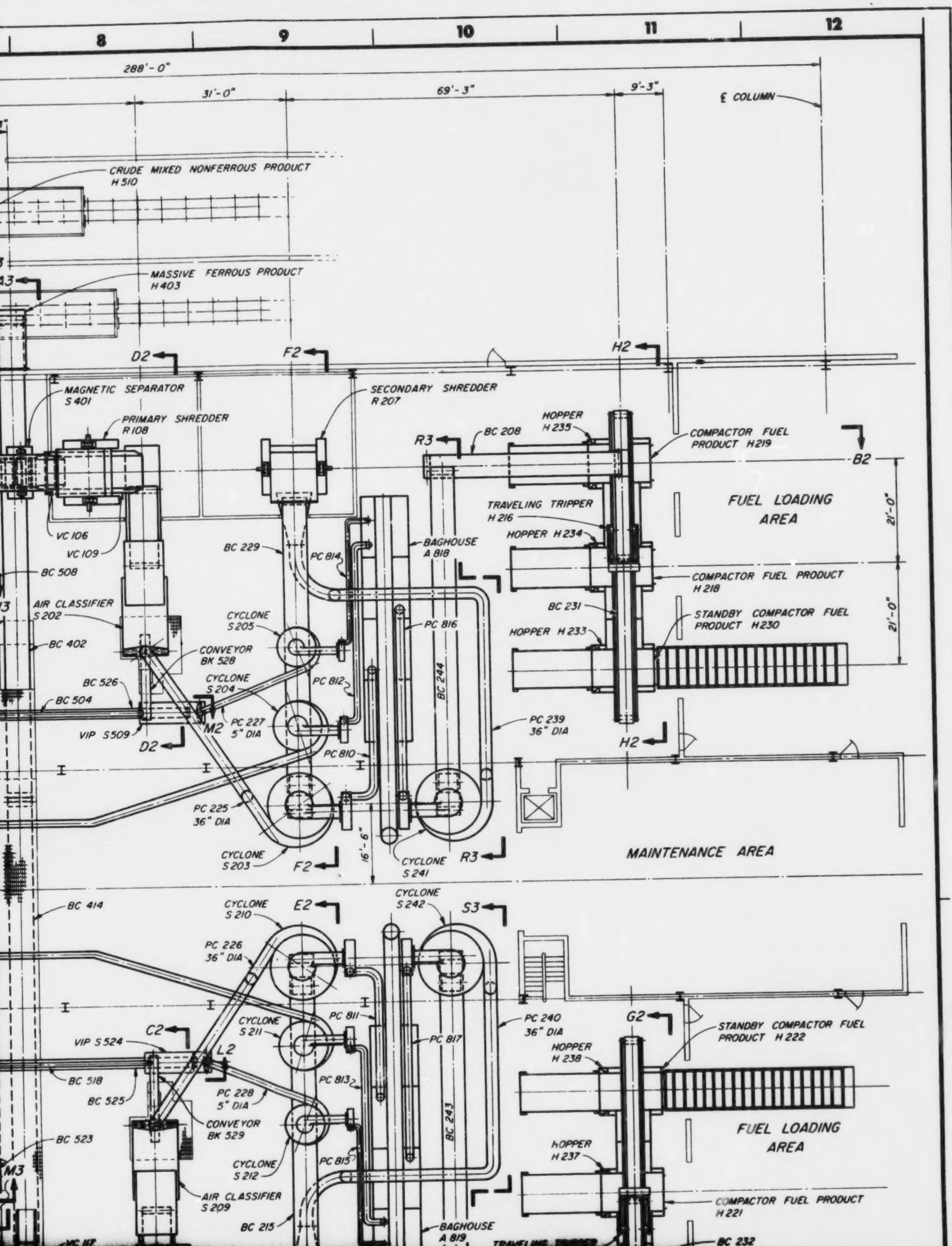
Annual waste processed - 728,000 tons.

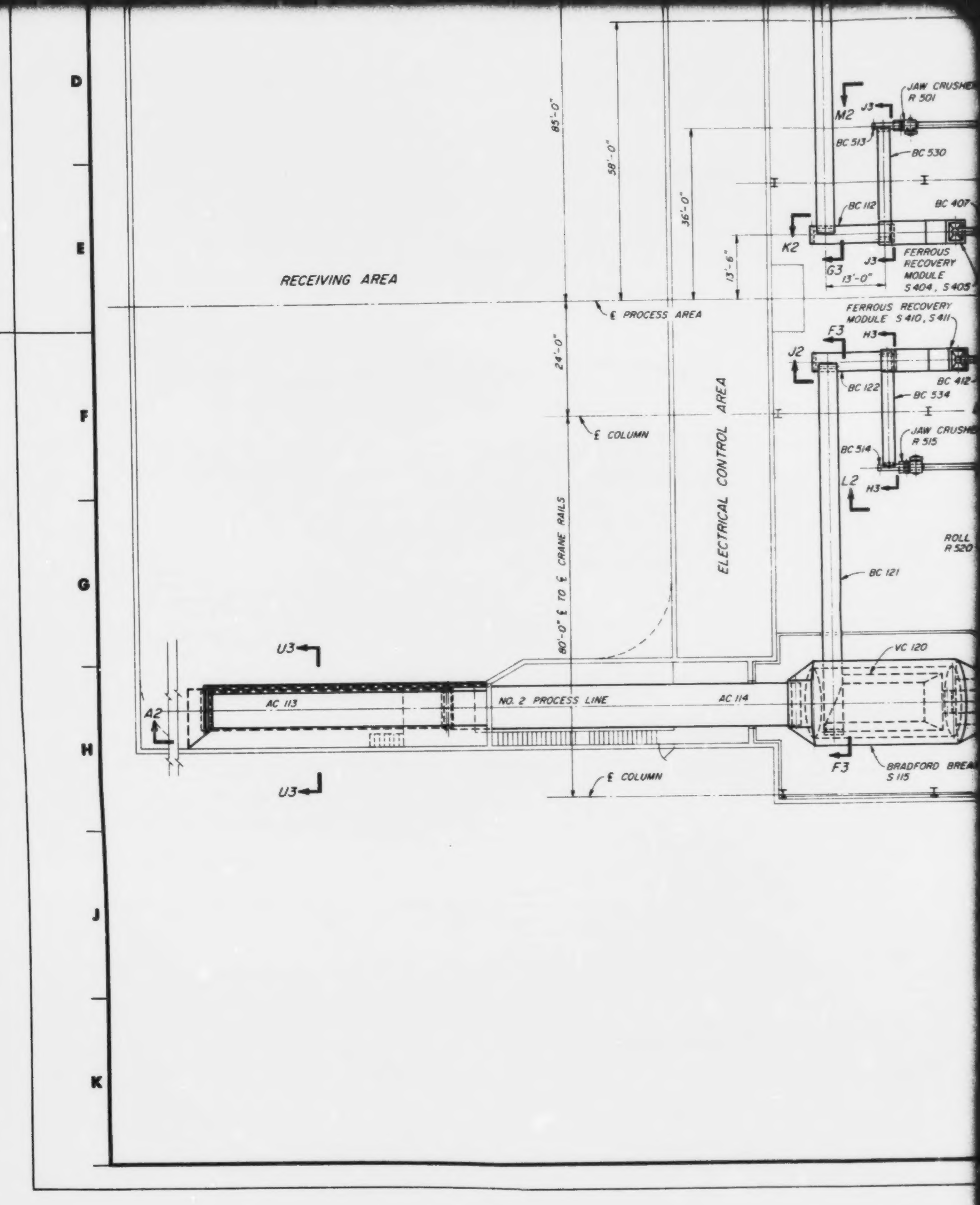


7GE0002-WD-01
1
2
3
4
5
A
B
C
D
E
F
G
①
℄ COLUMN
47'-0"
SPLITTER CHUTE
H 603
BC 609
CRUDE GLASS PRODUCT
H 604
CRUDE GLASS PRODUCT
H 605
E3
11'-0"
BRADFORD BREAKER
S 104
G3
V3
B2
AC 102
NO. 1 PROCESS LINE
AC 103
VC 110
BC 111
BC 416
85'-0"
58'-0"
36'-0"
13'-6"
JAW CRUSHER
R 501
M2
J3
BC 513
BC 530
BC 112
BC 407
K2
G3
J3
13'-0"
FERROUS
RECOVERY
MODULE
S 404, S 405
RECEIVING AREA
℄ PROCESS AREA
FERROUS RECOVERY
MODULE S 410, S 411
F3
H3
J2
BC 122
BC 412
BC 534
24'-0"
℄ COLUMN
JAW CRUSHER
R 515
BC 514
L2
H3
ELECTRICAL CONTROL AREA
ROLL
R 526
BC 121
80'-0" ℄ TO ℄ CRANE RAILS
U3
VC 120

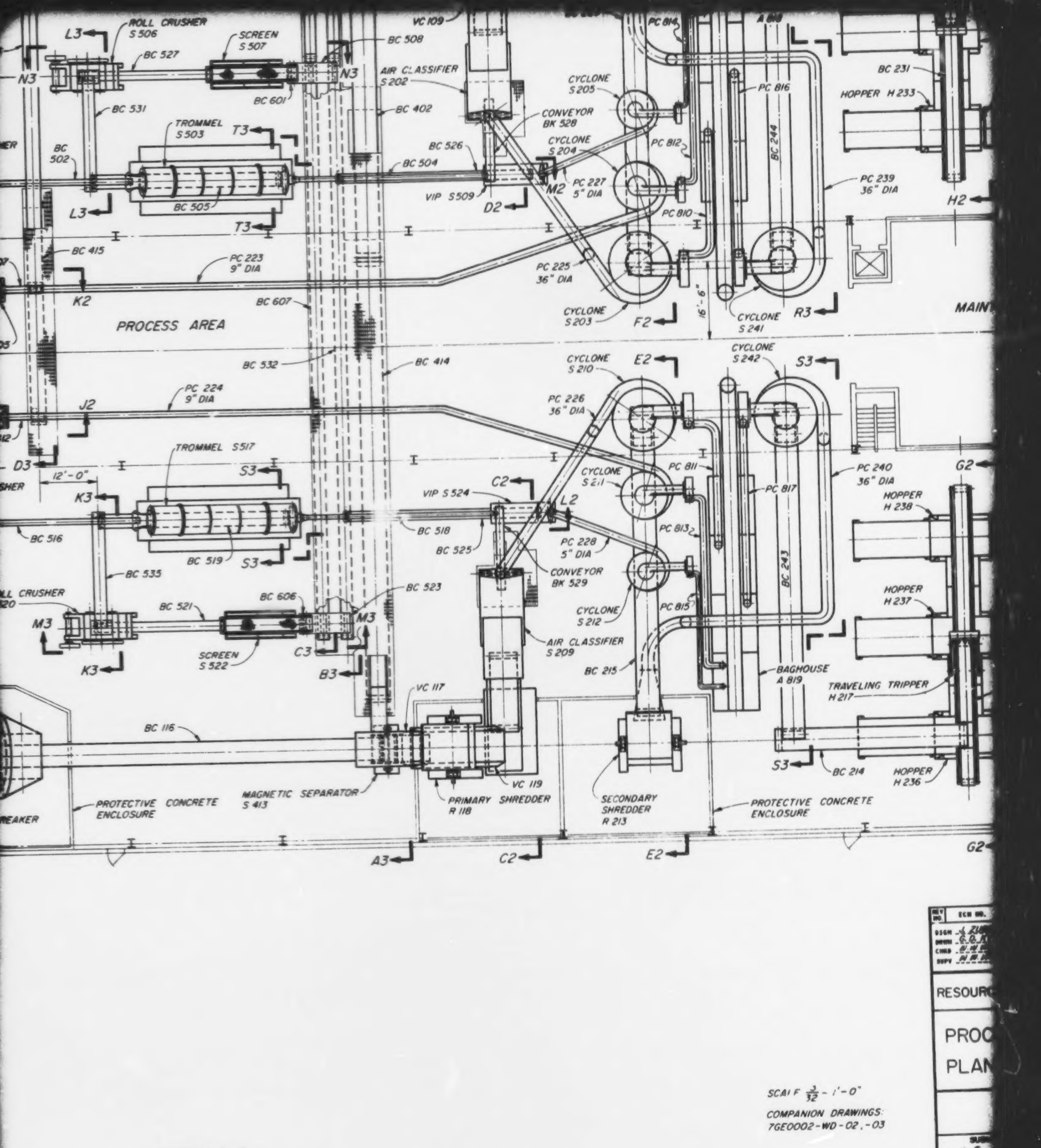


6
7
8
9
10
288'-0"
143'-6"
31'-0"
69'-3"
64'-0"
6'-3"
D3
CRUDE FERROUS PRODUCT
H 406
B3
CRUDE MIXED NONFERROUS PRODUCT
H 510
SPLITTER CHUTE
H 408
C3
E3
A3
MASSIVE FERROUS PRODUCT
H 403
CRUDE FERROUS PRODUCT
H 409
D2
F2
H2
EAKER
PROTECTIVE CONCRETE
ENCLOSURE
BC 608
MAGNETIC SEPARATOR
S 401
SECONDARY SHREDDER
R 207
5'-0"
PRIMARY SHREDDER
R 108
BC 533
R3
BC 208
HOPPER
H 235
BC 105
TRAVELING TRIPPER
H 216
VC 106
HOPPER H 234
VC 109
BC 229
BAGHOUSE
A 818
PC 814
ROLL CRUSHER
S 506
SCREEN
S 507
BC 508
L3
BC 416
BC 527
BC 231
N3
AIR CLASSIFIER
S 202
CYCLONE
S 205
PC 816
BC 601
HOPPER H 233
BC 531
BC 402
CONVEYOR
BK 528
TROMMEL
S 503
T3
CRUSHER
CYCLONE
S 204
BC 244
BC
502
BC 526
PC 812
BC 504
PC 227
5" DIA
PC 239
36" DIA
M2
VIP S509
BC 505
530
PC 810
T3
BC 415
BC 407
PC 223
9" DIA
PC 225
36" DIA
16'-6"
K2
ROUS
OVERY
ULE
4, S405
PROCESS AREA
BC 607
CYCLONE
S 203
CYCLONE
S 241
CYCLONE
S 242
VERY
S411
BC 532
BC 414
CYCLONE
S 210
E2
S3
PC 224
9" DIA
J2
PC 226
36" DIA
BC 412
C 534
TROMMEL S517
PC 811
PC 240
36" DIA
12'-0"
S3
CYCLONE
S 211
PC 817
CRUSHER
515
K3
C2
VIP S 524
L2
HOPPER
H 238
BC 516
BC 518
PC 813
BC 519
BC 525
PC 228
5" DIA
BC 243
BC 535
CONVEYOR
BK 529
ROLL CRUSHER
R 520
BC 606
BC 523
HOPPER
H 237
BC 521
M3
CYCLONE
S 212
PC 815
SCREEN
S 522
AIR CLASSIFIER
S 209
BC 215
BAGHOUSE
A 819
TRAVELING TRIPPER
H 217
VC 117


8
9
10
11
12
288'- 0"
31'- 0"
69'- 3"
9'- 3"
℄ COLUMN
CRUDE MIXED NONFERROUS PRODUCT H 510
MASSIVE FERROUS PRODUCT H 403
A3
D2
F2
H2
MAGNETIC SEPARATOR S 401
PRIMARY SHREDDER R 108
SECONDARY SHREDDER R 207
R3
BC 208
HOPPER H 235
COMPACTOR FUEL PRODUCT H 219
B2
FUEL LOADING AREA
21'-0"
21'-0"
TRAVELING TRIPPER H 216
HOPPER H 234
BAGHOUSE A 818
COMPACTOR FUEL PRODUCT H 218
VC 106
VC 109
BC 229
PC 814
BC 508
AIR CLASSIFIER S 202
BC 231
STANDBY COMPACTOR FUEL PRODUCT H 230
HOPPER H 233
CYCLONE S 205
PC 816
BC 402
CONVEYOR BK 528
CYCLONE S 204
PC 812
BC 244
BC 526
BC 504
PC 227 5" DIA
M2
VIP S 509
PC 239 36" DIA
PC 810
PC 225 36" DIA
CYCLONE S 203
16'-6"
CYCLONE S 241
MAINTENANCE AREA
BC 414
CYCLONE S 210
E2
CYCLONE S 242
S3
PC 226 36" DIA
PC 811
CYCLONE S 211
PC 240 36" DIA
G2
STANDBY COMPACTOR FUEL PRODUCT H 222
HOPPER H 238
VIP S 524
C2
L2
PC 817
BC 518
BC 525
PC 813
PC 228 5" DIA
CONVEYOR BK 529
BC 243
BC 523
FUEL LOADING AREA
HOPPER H 237
M3
CYCLONE S 212
PC 815
AIR CLASSIFIER S 209
COMPACTOR FUEL PRODUCT H 221
BC 215
BAGHOUSE A 819
TRAVELING TRIPPER
BC 232
VC 117



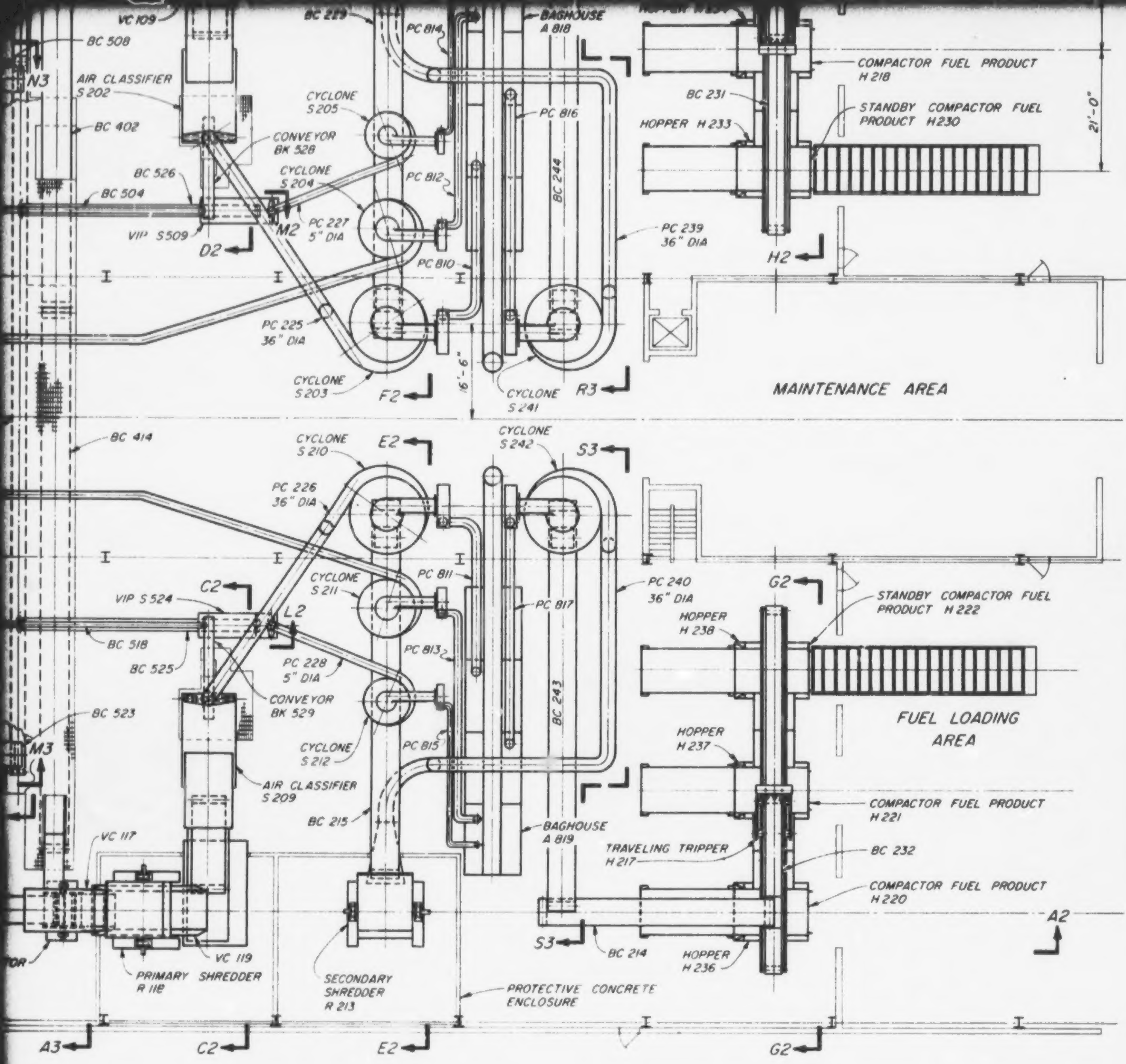
D
E
F
G
H
J
K
RECEIVING AREA
85'-0"
58'-0"
36'-0"
13'-6"
24'-0"
80'-0" ℄ TO ℄ CRANE RAILS
℄ PROCESS AREA
℄ COLUMN
℄ COLUMN
ELECTRICAL CONTROL AREA
M2
J3
JAW CRUSHE
R 501
BC 513
BC 530
BC 112
BC 407
K2
G3
J3
13'-0"
FERROUS RECOVERY MODULE S404, S405
FERROUS RECOVERY MODULE S410, S411
F3
H3
J2
BC 122
BC 412
BC 534
JAW CRUSHE
R 515
BC 514
L2
H3
ROLL
R 520
BC 121
VC 120
U3
U3
A2
AC 113
NO. 2 PROCESS LINE
AC 114
F3
BRADFORD BREA
S 115


ROLL CRUSHER S 506
SCREEN S 507
BC 527
BC 508
VC 109
PC 814
A 818
L3
N3
BC 601
AIR CLASSIFIER S 202
BC 402
CYCLONE S 205
PC 816
BC 231
HOPPER H 233
BC 531
TROMMEL S 503
T3
CONVEYOR BK 528
BC 502
BC 526
BC 504
CYCLONE S 204
PC 812
BC 244
BC 505
VIP S509
D2
M2
PC 227 5" DIA
PC 239 36" DIA
H2
PC 810
BC 415
PC 223 9" DIA
PC 225 36" DIA
K2
BC 607
PROCESS AREA
CYCLONE S 203
F2
16'-6"
CYCLONE S 241
R3
MAIN
BC 532
BC 414
CYCLONE S 210
E2
CYCLONE S 242
S3
PC 224 9" DIA
J2
PC 226 36" DIA
D3
12'-0"
TROMMEL S517
CYCLONE S 211
PC 811
PC 817
PC 240 36" DIA
G2
K3
VIP S 524
C2
L2
HOPPER H 238
BC 516
BC 518
BC 525
PC 813
BC 243
PC 228 5" DIA
BC 519
CONVEYOR BK 529
BC 535
BC 523
ROLL CRUSHER
BC 606
BC 521
M3
CYCLONE S 212
PC 815
HOPPER H 237
AIR CLASSIFIER S 209
SCREEN S 522
C3
B3
BC 215
BAGHOUSE A 819
TRAVELING TRIPPER H 217
VC 117
BC 116
VC 119
BC 214
HOPPER H 236
PROTECTIVE CONCRETE ENCLOSURE
MAGNETIC SEPARATOR S 413
PRIMARY SHREDDER R 118
SECONDARY SHREDDER R 213
PROTECTIVE CONCRETE ENCLOSURE
REAKER
A3
RESOURC
PROC
PLAN
KNOXVIL
PRINT
SIZE

SCALE 3/32 - 1'-0"

COMPANION DRAWINGS: 7GE0002-WD-02,-03

FIGURE 7-1


VC 109
BC 229
BAGHOUSE
A 818
BC 508
N3
AIR CLASSIFIER
S 202
BC 402
PC 814
COMPACTOR FUEL PRODUCT
H 218
BC 231
STANDBY COMPACTOR FUEL
PRODUCT H230
21'-0"
CYCLONE
S 205
PC 816
HOPPER H 233
CONVEYOR
BK 528
BC 244
BC 526
CYCLONE
S 204
PC 812
BC 504
M2
PC 227
5" DIA
PC 239
36" DIA
VIP S509
D2
H2
PC 810
PC 225
36" DIA
16'-6"
CYCLONE
S 203
F2
CYCLONE
S 241
R3
MAINTENANCE AREA
BC 414
CYCLONE
S 210
E2
CYCLONE
S 242
S3
PC 226
36" DIA
CYCLONE
S 211
PC 811
PC 240
36" DIA
G2
VIP S 524
C2
L2
PC 817
HOPPER
H 238
STANDBY COMPACTOR FUEL
PRODUCT H 222
BC 518
BC 525
PC 228
5" DIA
PC 813
CONVEYOR
BK 529
BC 243
BC 523
M3
CYCLONE
S 212
PC 815
HOPPER
H 237
FUEL LOADING
AREA
AIR CLASSIFIER
S 209
BC 215
BAGHOUSE
A 819
COMPACTOR FUEL PRODUCT
H 221
VC 117
TRAVELING TRIPPER
H 217
BC 232
COMPACTOR FUEL PRODUCT
H 220
A2
TOR
VC 119
S3
BC 214
HOPPER
H 236
PRIMARY SHREDDER
R 118
SECONDARY
SHREDDER
R 213
PROTECTIVE CONCRETE
ENCLOSURE
A3
C2
E2
G2

SCALE $\frac{3}{32}$ - 1'-0"

COMPANION DRAWINGS
7GE0002-WD-02, -03

REV NO	ECN NO.	DATE	DSGN	DRWN	CHKD	SUPV	ENGR	INSP			APPD				

DSGN J. ZUBER
DRWN G. D. KYTE
CHKD W. W. WOODS
SUPV W. W. WOODS
INSP
ENGINEER

RESOURCE RECOVERY - MUNICIPAL SOLID WASTE

PROCESSING PLANT ·LAYOUT
PLAN

SITE - NONSPECIFIC
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
	J. B. Andrews Jr.	S. Kesler

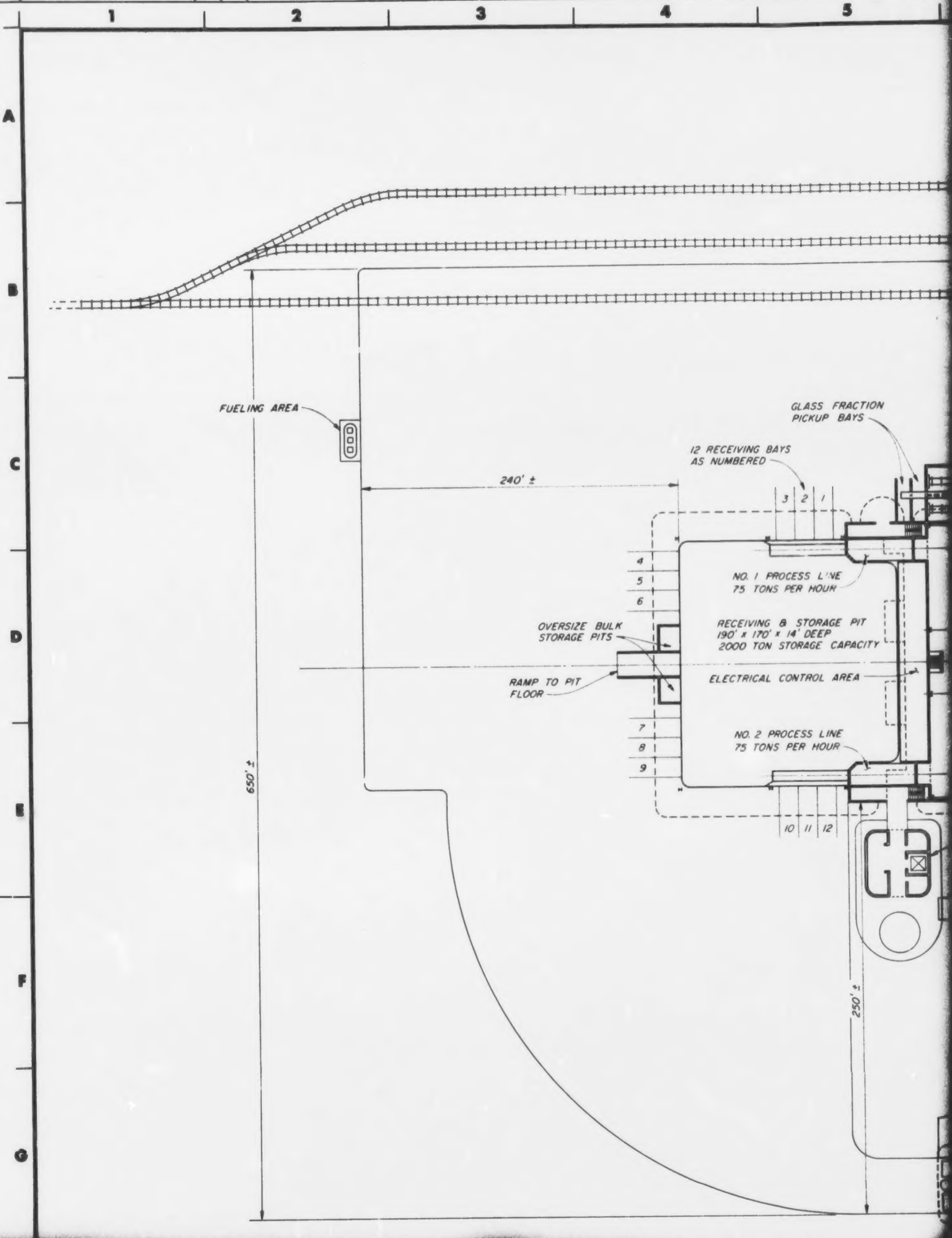
KNOXVILLE

7GE0002-WD-01 RO

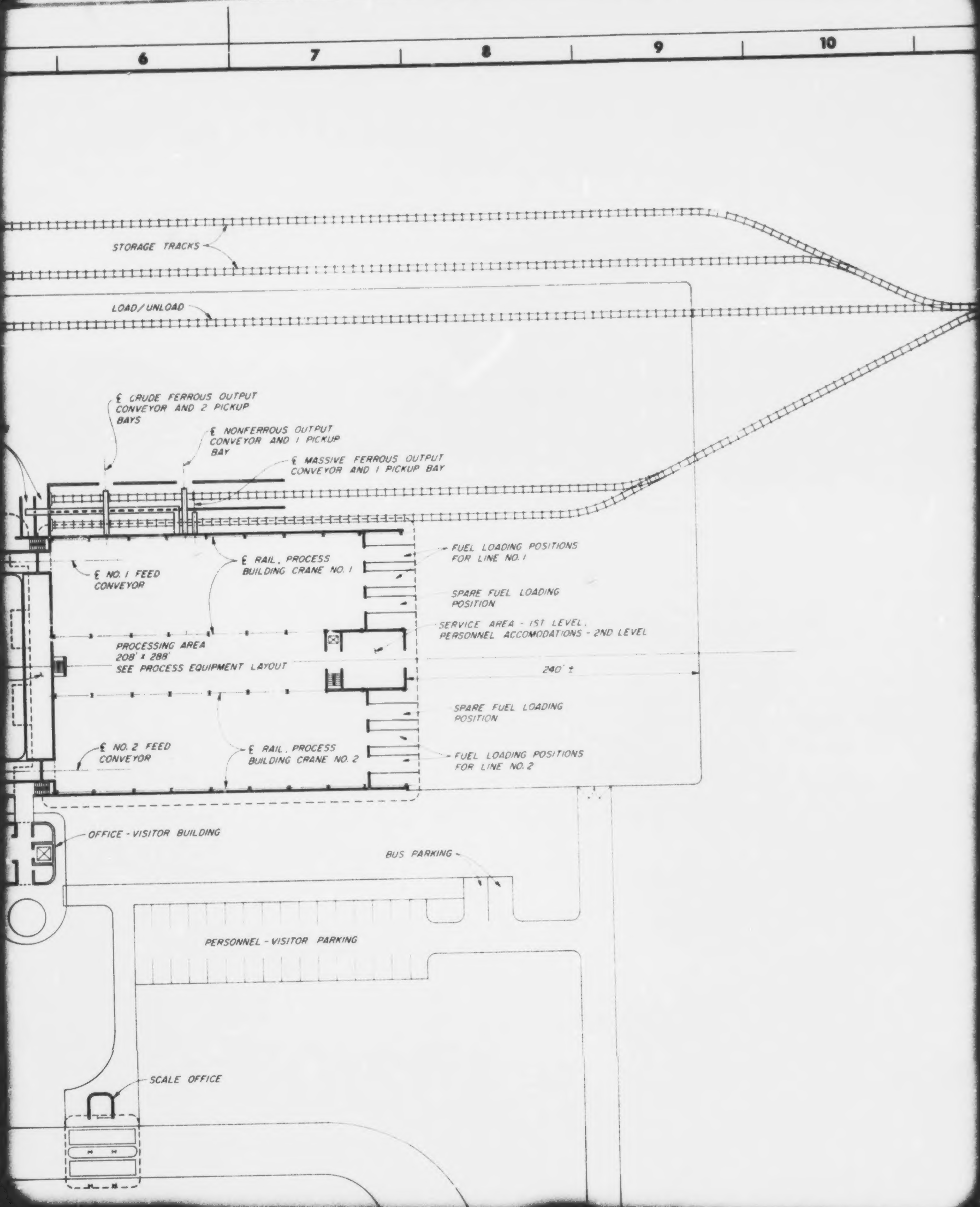
RECORD DRAWING AS CONSTRUCTED

PRINT
SIZE

7GE0001 - WD-01



1
2
3
4
5
A
B
C
D
E
F
G
FUELING AREA
GLASS FRACTION PICKUP BAYS
12 RECEIVING BAYS AS NUMBERED
240' ±
3 2 1
4
5
6
NO. 1 PROCESS LINE 75 TONS PER HOUR
OVERSIZE BULK STORAGE PITS
RECEIVING & STORAGE PIT 190' x 170' x 14' DEEP 2000 TON STORAGE CAPACITY
RAMP TO PIT FLOOR
ELECTRICAL CONTROL AREA
7
8
9
NO. 2 PROCESS LINE 75 TONS PER HOUR
10 11 12
650' ±
250' ±


6
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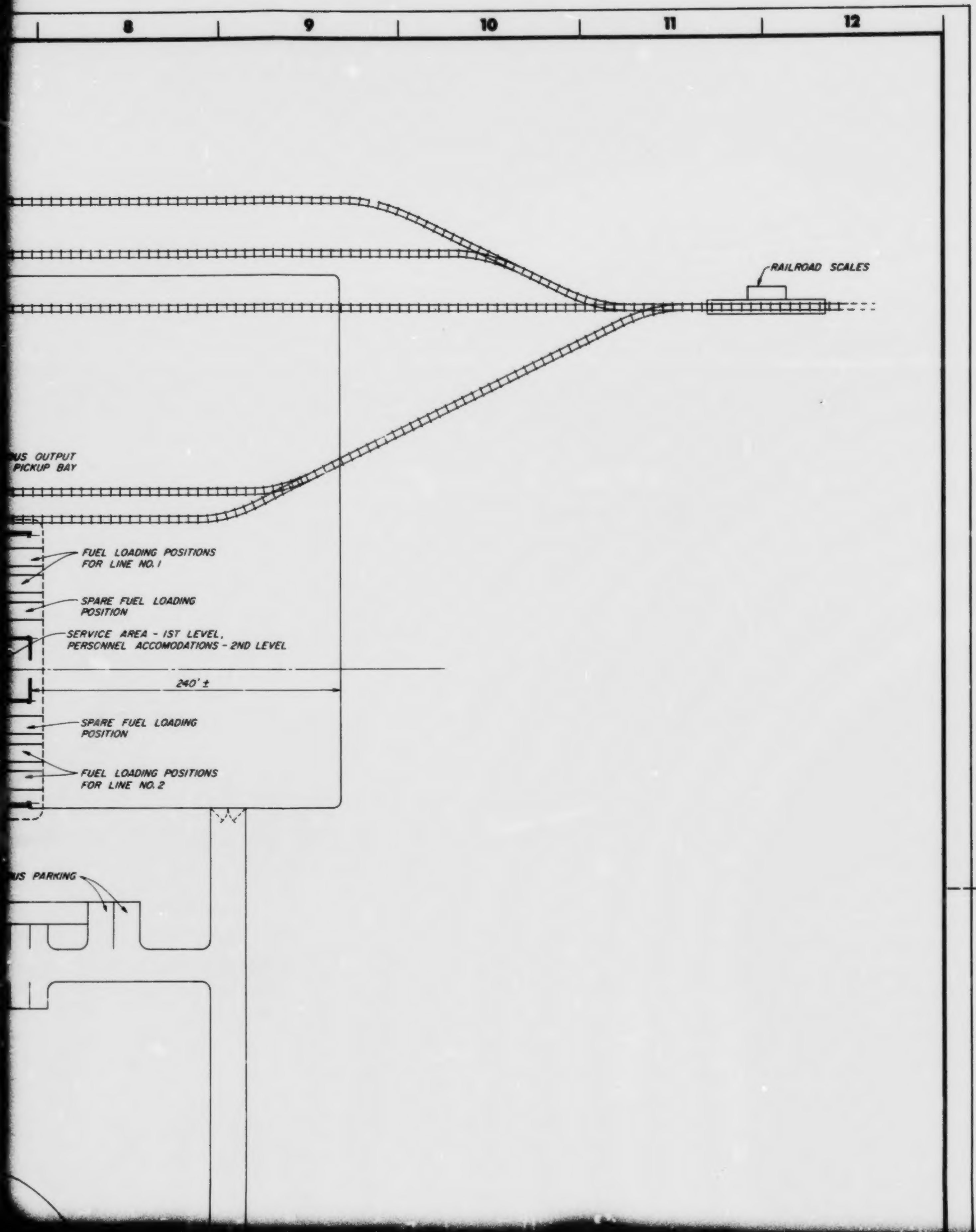
STORAGE TRACKS
LOAD/UNLOAD
℄ CRUDE FERROUS OUTPUT CONVEYOR AND 2 PICKUP BAYS
℄ NONFERROUS OUTPUT CONVEYOR AND 1 PICKUP BAY
℄ MASSIVE FERROUS OUTPUT CONVEYOR AND 1 PICKUP BAY
℄ NO. 1 FEED CONVEYOR
℄ RAIL, PROCESS BUILDING CRANE NO. 1
FUEL LOADING POSITIONS FOR LINE NO. 1
SPARE FUEL LOADING POSITION
SERVICE AREA - 1ST LEVEL, PERSONNEL ACCOMODATIONS - 2ND LEVEL
PROCESSING AREA 208' x 288' SEE PROCESS EQUIPMENT LAYOUT
240' ±
SPARE FUEL LOADING POSITION
℄ NO. 2 FEED CONVEYOR
℄ RAIL, PROCESS BUILDING CRANE NO. 2
FUEL LOADING POSITIONS FOR LINE NO. 2
OFFICE - VISITOR BUILDING
BUS PARKING
PERSONNEL - VISITOR PARKING
SCALE OFFICE


8
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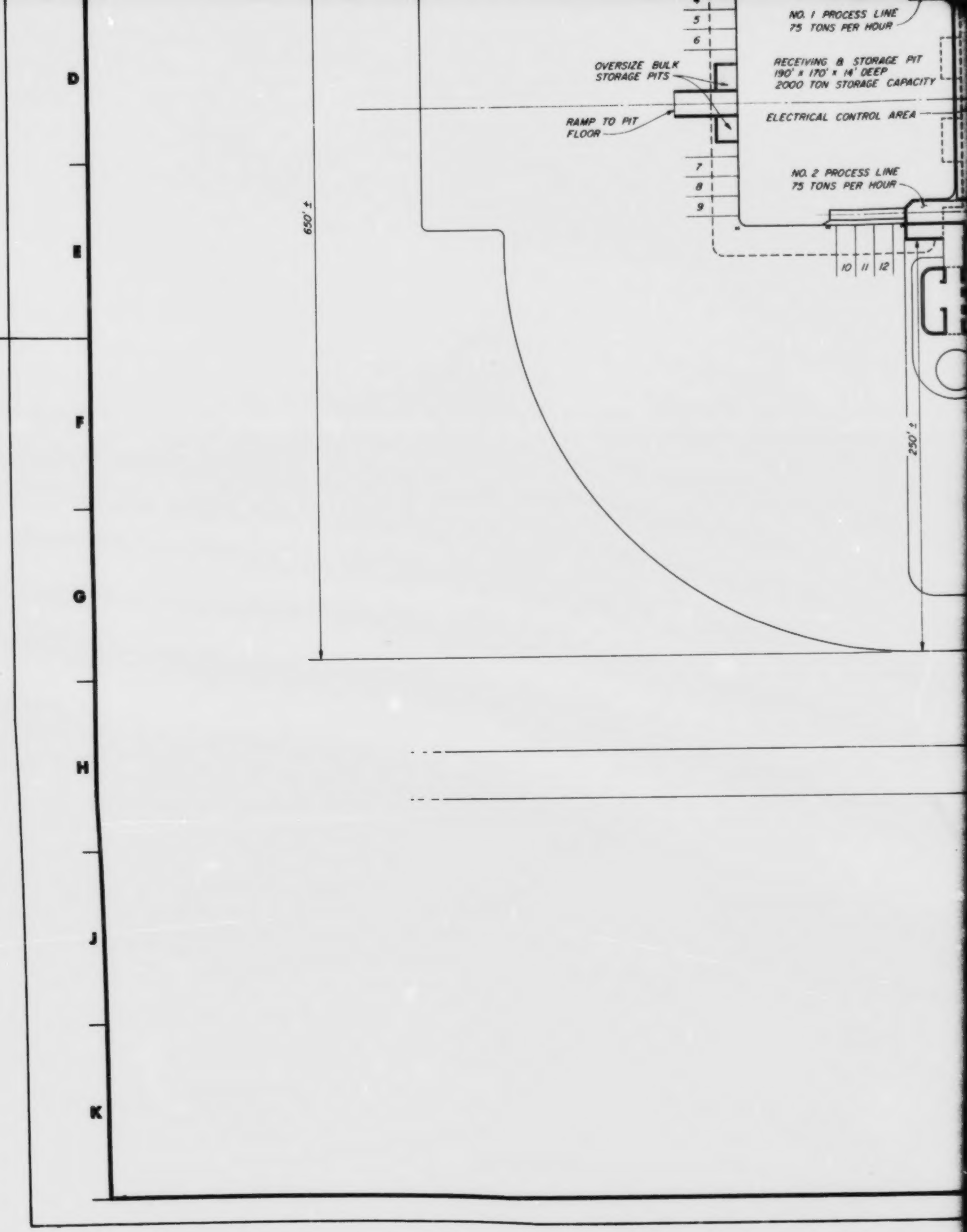
12
RAILROAD SCALES
US OUTPUT
PICKUP BAY
FUEL LOADING POSITIONS
FOR LINE NO. 1
SPARE FUEL LOADING
POSITION
SERVICE AREA - 1ST LEVEL,
PERSONNEL ACCOMODATIONS - 2ND LEVEL
240' ±
SPARE FUEL LOADING
POSITION
FUEL LOADING POSITIONS
FOR LINE NO. 2
US PARKING


D
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12
NO. 1 PROCESS LINE
75 TONS PER HOUR
OVERSIZE BULK
STORAGE PITS
RECEIVING & STORAGE PIT
190' x 170' x 14' DEEP
2000 TON STORAGE CAPACITY
RAMP TO PIT
FLOOR
ELECTRICAL CONTROL AREA
NO. 2 PROCESS LINE
75 TONS PER HOUR
650' ±
250' ±

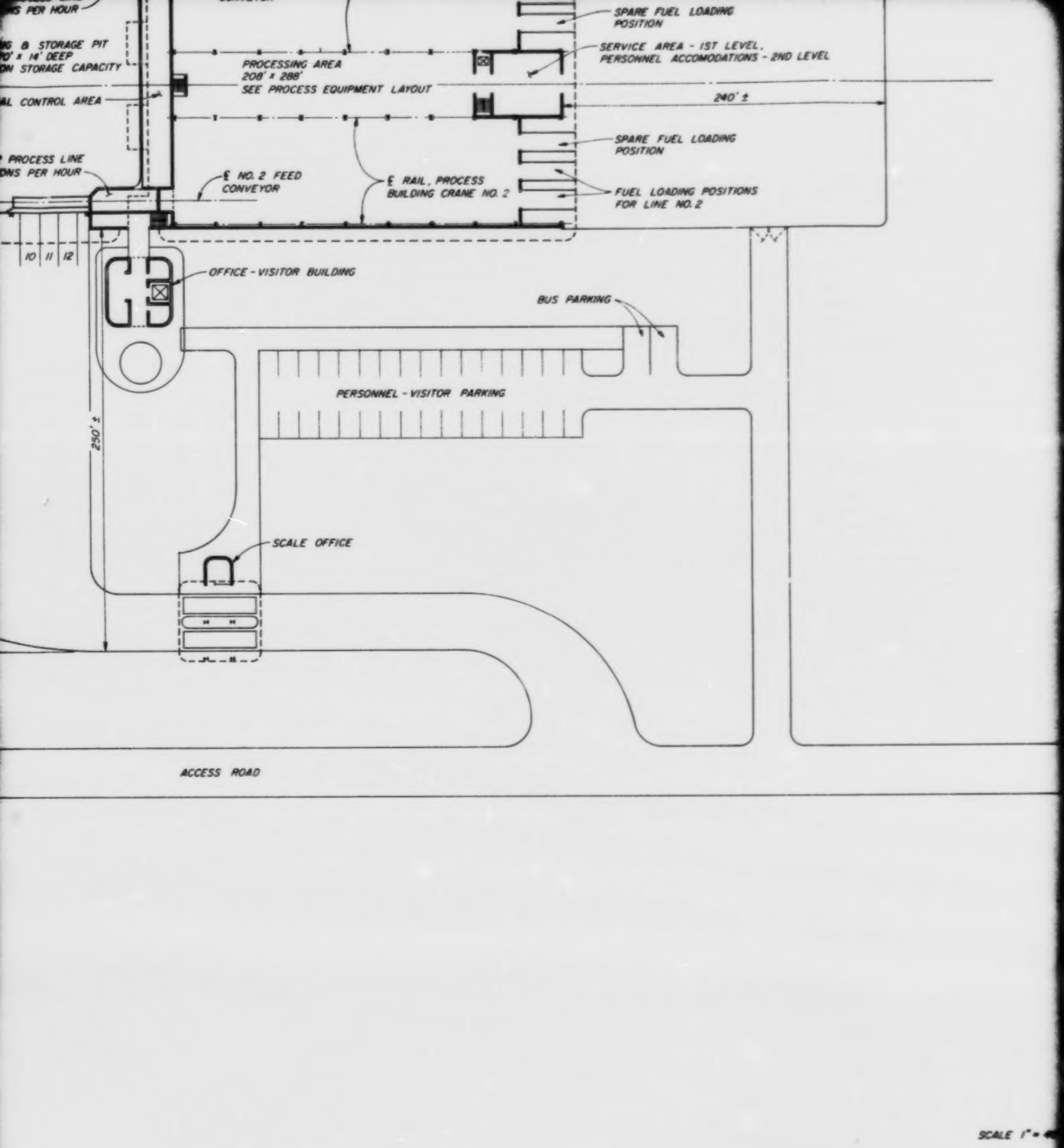
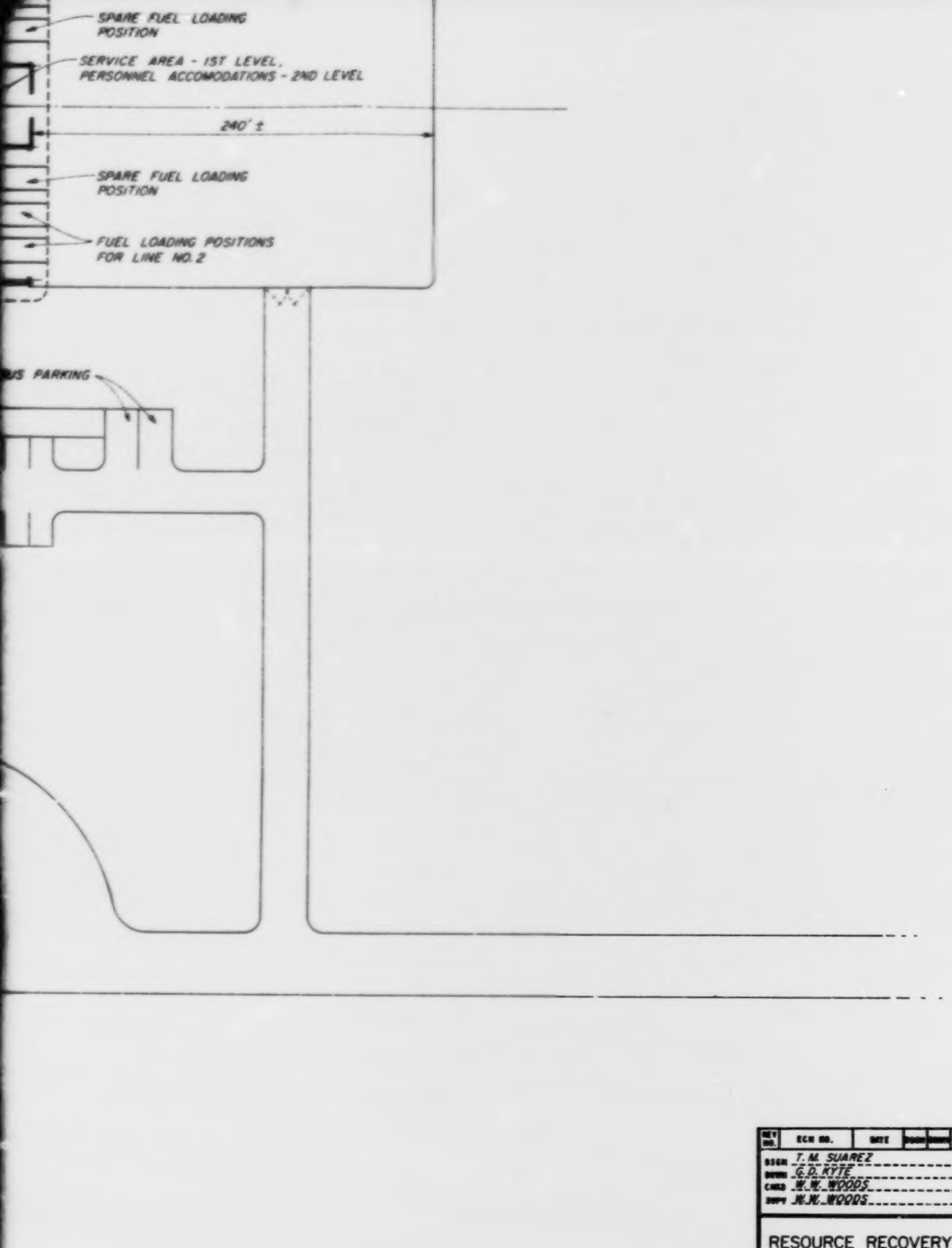

NS PER HOUR
NG & STORAGE PIT
70' x 14' DEEP
ON STORAGE CAPACITY
AL CONTROL AREA
PROCESS LINE
ONS PER HOUR
PROCESSING AREA
208' x 288'
SEE PROCESS EQUIPMENT LAYOUT
SPARE FUEL LOADING POSITION
SERVICE AREA - 1ST LEVEL,
PERSONNEL ACCOMODATIONS - 2ND LEVEL
240' ±
SPARE FUEL LOADING POSITION
℄ NO. 2 FEED CONVEYOR
℄ RAIL, PROCESS BUILDING CRANE NO. 2
FUEL LOADING POSITIONS FOR LINE NO. 2
10
11
12
OFFICE - VISITOR BUILDING
BUS PARKING
PERSONNEL - VISITOR PARKING
250' ±
SCALE OFFICE
ACCESS ROAD
SCALE 1" = 4

FIGURE 7-2


SPARE FUEL LOADING POSITION
SERVICE AREA - 1ST LEVEL, PERSONNEL ACCOMODATIONS - 2ND LEVEL
240' ±
SPARE FUEL LOADING POSITION
FUEL LOADING POSITIONS FOR LINE NO. 2
US PARKING

SCALE 1" = 40'-0"

REV NO.	ECN NO.	DATE	DSGN	DRWN	CHKD	SUPV	ENGR	INSP	SUBMD	RECD	APVD

DSGN T. M. SUAREZ
DRWN G. D. KYTE
CHKD W. W. WOODS
SUPV W. W. WOODS
INSP
ENGINEER

RESOURCE RECOVERY - MUNICIPAL SOLID WASTE

SITE PLAN

SITE - NONSPECIFIC
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

SUBMITTED	RECOMMENDED	APPROVED
	J B Anderson Jr.	S. Kesler

KNOXVILLE
7GE0001 - WD - 01 R0
RECORD DRAWING AS CONSTRUCTED

PRINT	H						/									
SIZE	F															

BR OR PROJ ME EE CE AD CD ED MD SF SU EL PA
PRINTS REQD-R

Annual ferrous metals product - 72,800 tons.

Projected ferrous metals revenue per ton of waste processed:

$$\frac{(72{,}800\ \text{TPY})(\$45/\text{Ton})}{728{,}000\ \text{TPY}} = \$4.50$$

Aluminum - Bid data indicates that aluminum can be marketed f.o.b. TVA's processing plant at 54 percent ± of 99.5 ingot price, or conservatively speaking $540/ton. At today's prices this would amount to $442 per ton. By 1979 the 99.5 ingot price is expected to average not less than 50 cents per pound.

Approximately 1 percent of the waste processed is expected to be aluminum.

Annual waste processed - 728,000 tons.

Annual aluminum recovered at 90 percent recovery efficiency - 7,280 tons x 0.90 = 6,550 tons.

Projected aluminum revenue per ton of waste processed:

$$\frac{(6{,}550\ \text{TPY})(\$540/\text{Ton})}{728{,}000\ \text{TPY}} = \$4.86/\text{ton}$$

The average annual cost of aluminum recovery using two aluminum magnet recovery modules would be approximately $50 per ton of aluminum recovered or 44 cents per ton of waste processed.

Net revenue per ton processed $4.86 - $0.44 = $4.40 net revenue.

Nonferrous metals excluding aluminum - Useful bid information on this product was not received due to the lack of a good bid mechanism. However, based on recent market studies, industry appears to be willing to purchase this product on a spot-sale basis. The most likely purchaser of this product will be industries utilizing heavy media separation techniques to recover the metals. The accepted method for payment is for metal actually derived. The value assigned is usually 10 cents to 20 cents per pound. For this study a value of 10 cents per pound or $200/ton was used.

Approximately 0.25 percent of the waste processed is expected to be recovered as nonferrous metals excluding aluminum.

Annual waste processed - 728,000 tons.

Annual nonferrous metals excluding aluminum - 1,420 tons.

Projected nonferrous revenue per ton of waste processed:

$$\frac{(1,420 \text{ TPY})(\$200/\text{ton})}{728,000 \text{ TPY}} = \$0.50/\text{ton}$$

Froth-floated mixed color glass - The glass product offered for sale in the bid document was a high quality froth-floated glass cullet with a specification guarantee. No bids were received since any successful bidder would be required to purchase the entire plant output. Since this was expected, the National Center for Resource Recovery was retained to work concurrently under contract to TVA to develop a market for this product. NCRR secured letters of intent from glass companies to purchase over 60,000 tons per year at a minimum floor price of $15 with a five-year commitment to purchase. It now appears that all the glass product can be sold at $15 per ton f.o.b. the glass purchaser's place of business. It has been estimated by both NCRR and The Bureau of Mines that the glass product from a 2,000-ton-per-day can be produced for $5 to $8 per ton. If one allows another $5 per ton for transportation to the various glass plants, then net revenue would be $5 to $10 per ton. (NCRR's report describing the glass recovery module and the economics of glass recovery is available from TVA on request.)

Approximately 10 percent of the waste processed is expected to be recovered as a glass product.

Annual waste processed - 728,000 tons.

Annual glass product - 72,800 tons.

Projected glass product revenue per ton of waste processed:

$$\frac{(72,800 \text{ TPY})(\$5/\text{ton})}{728,000} = \$0.50/\text{ton}$$

The total non-fuel revenue potential is summarized as follows:

Product	Potential Revenue Per Ton of Waste Processed
Ferrous metals	$4.50
Aluminum	4.40
Nonferrous metals, excluding aluminum	0.50
Froth-floated glass	0.50
Total	$9.90

(Bid document attached)

TVA 9650 (OP-12-71)

TENNESSEE VALLEY AUTHORITY

DIVISION OF PURCHASING
CHATTANOOGA, TENNESSEE 37401

No. 42-3166

Telephone Area 615 755-2801

SALES INVITATION, BID, AND ACCEPTANCE

INVITATION Date August [illegible], 1976

Written bids, subject to the conditions set forth herein, for purchasing from TVA any or all items listed on the accompanying schedule, will be received at the office of the Surplus Property Unit, Division of Purchasing, Chattanooga, Tenn. 37401, until 2:00 o'clock p.m., September [illegible], 1976 *, and will be opened and read in public. Items are to be sold as shown in the attached Sales Contract Schedule "as is" without recourse, in accordance with the ~~General~~ Conditions of Sale ~~and any Special Conditions~~. Bids not physically received by the time stated will be returned unopened to the bidder.

TENNESSEE VALLEY AUTHORITY By Joe C. Sparkman
Property and Supply Officer

INSTRUCTIONS TO BIDDERS

1. Bid on this form. If an award is made to you, TVA will complete the ACCEPTANCE portion of this form listing the items awarded and notify you by a copy.
2. Use the enclosed addressed label for returning your bid. It is essential that you complete the spaces provided for your name, address, invitation number, and the date and hour of bid opening for identification and to avoid delay in handling the bid. Seal envelope containing your bid.
3. Return one copy of bid.

* Local time at Chattanooga, Tennessee

BID

Date ....

FOR SALE

In compliance with the above invitation for bids, and subject to all the conditions and terms thereof, the undersigned offers and agrees, if this bid be accepted within June 1, 1976 ~~days (10 days if no time is specified) from the date of opening~~, to purchase any or all items upon which prices are quoted on the accompanying schedule at the price set opposite each item. ~~Bids~~ [illegible] ~~may be rejected.~~
~~The property~~ [illegible]

Complete only when (a) the aggregate amount of bid in response to advertising is $25,000 or more, or (b) the aggregate amount of bid on a negotiated purchase is more than $1,000:

That (a) he has ________, has not ________, employed or retained any company or person [other than bona fide employees or bona fide established commercial or selling agencies maintained by the bidder (or contractor) for purposes of securing business] to solicit or secure this contract; and (b) he has ________, has not ________, paid or agreed to pay any company or person [other than bona fide employees or bona fide established commercial or selling agencies maintained by the bidder (or contractor) for purposes of securing business] any fee, commission, percentage or brokerage fee, contingent upon or resulting from the award of this contract, and agrees to furnish information relating thereto as requested by the Contracting Officer.

Bidder	Street		
	City	State	Zip Code
Signature (Do Not Print) and title of person authorized to sign bid	P. O. Box Number	P. O. Box Zip Code	Telephone

FOR TVA USE

ACCEPTANCE

TVA USE ONLY

Accepted only as to:

Date ____________________
Amount ____________________
Sales Tax ____________________
Total ____________________

TENNESSEE VALLEY AUTHORITY

By ____________________
Property and Supply Officer
Joe C. Sparkman,

TVA'S PROPOSAL TO CONSTRUCT REGIONAL SOLID WASTE RECOVERY SYSTEMS TO RECOVER FUEL PRODUCTS AND VALUABLE METALS, GLASS, AND OTHER MARKETABLE PRODUCTS TO BE OFFERED FOR SALE TO THE GENERAL PUBLIC

During the past year, the Tennessee Valley Authority has been investigating the feasibility of establishing a regional solid waste recovery system to serve the TVA region (see attached map). This project, while providing a solid waste disposal system for the TVA region, will recover a supplemental fuel product for use in TVA's coal-fired power plants and return to the recycling stream valuable metals and glass now being discarded in landfills throughout the region.

On February 6, 1975, the TVA Board authorized Phase I of this project, which is a detailed engineering study to determine project feasibility and implementation schedules. This study is scheduled for completion by September 1, 1975. At that time, if the project proves feasible, recommendations will be made to the TVA Board regarding Phase II, the construction phase. Before this decision can be made, we need accurate information on the revenue potential of this project.

Two schedules are being considered in the design of the processing plants. Schedule I involves processing the waste to recover four products: (1) fuel, (2) bulk ferrous metals including can scrap, (3) mixed-color glass, and (4) nonferrous metal. Under this schedule, TVA may recover aluminum cans from the nonferrous metals and offer them as an optional product. Schedule II involves splitting the waste stream into two fractions: (1) fuel and (2) an unsegregated heavy fraction, each of which would constitute approximately 50 percent by weight of the incoming refuse. TVA plans to retain the fuel product in either schedule. However; to stimulate industries' interest in developing a more profitable use for the fuel product, TVA plans to make available for purchase approximately 500 tons per day. If your company is interested in purchasing one or more of these products, please offer a formal bid on the attached bid forms.

TVA's current plans are that one processing plant would be constructed, initially, in the Knoxville area. This processing plant is scheduled to go into production by mid-year 1979, and is expected to process 3,000 tons per day, 6 days per week, or 18,000 tons per week of mixed municipal solid waste. One other plant with equal capacity is under consideration and would likely be brought on line within 2 years. Products from that plant may be offered for sale at a later date. The estimated quality and quantity of recoverable products and bid instructions are attached. Bids are to be firm for the number of specified years for percentage of published price, price per pound, or ton as applicable for each item offered. If TVA is not producing marketable products by January 1, 1980, Contractor may at his option cancel the product purchase contract by giving written notice to TVA by January 31, 1980.

GENERAL INFORMATION FOR BIDDERS TO EVALUATE PROPOSED PRODUCTS OFFERED FOR SALE

I. Description of Typical Processing Plant

Processing plants in both Schedule I and Schedule II will be capable of processing 3,000 tons of raw municipal solid waste per day, six days per week. The incoming waste will not be subject to presorting and will consist of:

> General household, commercial, industrial, and institutional refuse as collected by private, commercial, or municipal refuse haulers.

Typical flow diagrams for both processing plant schedules are attached as Appendix 1. As shown on the flow diagrams, the marketable products proposed will be·

Schedule I

1. All ferrous metals (including bulk and other ferrous scrap)
2. Mixed-color froth-floated glass
3. Mixed nonferrous metals including aluminum cans
4. Aluminum cans (optional)
5. Light fraction fuel product

Schedule II

1. Unsegregated heavy fraction (contains all material other than light fuel fraction removed)
2. Light fraction fuel product

The qualities and quantities of each are described in items II and III.

II. Quality of Marketable Products

Schedule I

Ferrous Scrap--The ferrous product will be removed at two points in each processing line. There will be three processing lines in the 3,000 ton-per-day plant (six points of removal). The bulky items such as white goods will be removed by TVA prior to the processing lines and placed in purchasers conveyance. The purchaser will be required to provide the separation equipment for the remaining ferrous and, therefore, will have control of the quality of the ferrous removed.

In each processing line, TVA will by trommeling size separate the ferrous into two fractions: (1) an undersize fraction (nominal 4 in. or less) and (2) an oversize fraction (nominal greater than 4 in.). No shredding will be performed prior to magnetic separation. The combined ferrous product mix following magnetic separation is estimated to be as follows.

	Percent by Weight
Tin container	45%
Other containers	30%
All other ferrous (coat hanger, auto parts, toys, wire, etc.)	25%
	100%
Estimated nonferrous tramp included in the above percentages	205 - 24%

(Tramp includes paper, plastics, glue, rags, enamels & lacquers, grease, dirt, and nonferrous metals.)

Density - 7 to 8 lbs. per cubic foot

Total ferrous is estimated to be 11 percent of incoming municipal solid waste. One percent is bulky and will be that removed by TVA prior to trommeling. Approximately 8 percent will fall into the undersize fraction and 2 percent will go with the oversize fraction. Since the contractor's equipment will control the quality of this product, TVA offers no quality guarantee.

Glass--The glass will be a mixed-color glass cullet with a size distribution in the range of 20 to 150 mesh. Systems such as those designed by the Bureau of Mines, Garrett Research and Development Company, or NCRR will be used to produce a glass of approximately 99 percent purity. The bulk density of this material should be in the 90 to 100 pounds per one cubic foot range. TVA will guarantee the product specifications as shown in Appendix 2.

Mixed Nonferrous--The mixed nonferrous product will be approximately 20 percent metals and 80 percent contaminants. The nonferrous product may or may not contain the aluminum cans and should be bid both ways. The bulk density of this product will be approximately 30 pounds per cubic foot. No quality guarantees are made for this product.

Aluminum--The aluminum product will be mainly aluminum cans and foil. Recovery will be accomplished using aluminum magnet techniques. TVA will guarantee the product specifications as shown in Appendix 3.

Light Fraction Fuel Product--The fuel product, if taken after primary shredding, will have a nominal size of approximately 4 to 6 inches. If taken after secondary shredding, the nominal particle size will be approximately 3/4 inch with approximately 90 percent less than 1/2 inch. Ash content will be approximately 12 to 15 percent. Moisture content will be approximately a maximum of 25 percent. The fuel product from this item under this schedule will be offered two ways: (1) with primary shredding and (2) with secondary shredding. No quality guarantees are made for this product.

Schedule II

Unsegregated Heavy Fraction--To produce this product, TVA plans to extract most of the lightweight combustible products, amounting to about 50 to 60 percent of the total municipal solid waste processed, to use as supplemental fuel in TVA's power plants. To accomplish this, TVA proposes to use a large trommel air classifier that will provide this split on unshredded raw refuse. The unsegregated heavy fraction will be the heavy fraction of the waste stream. It will contain most of the metals, glass, combustibles, and organic materials not removed as fuel. No attempt will be made by TVA to provide further cleanup of this unsegregated heavy fraction. Bidder will be required to accept as is. No specifications are included for this product. However; based on TVA's waste sampling studies, an estimate is being provided for the expected quantity of metal and glass constituents in this product. No quality guarantees are made for this product.

Light Fraction Fuel Product--The fuel product from this schedule will be offered three ways: (1) with no shredding, (2) with primary shredding, and (3) with secondary shredding. With no shredding, the ash content is expected to be between 15 to 20 percent; if primary or secondary shredding is required, the fuel product will be the same as that described in Schedule I. No quality guarantees are made for this product.

III. Quantity of Products Available for Purchase

According to sampling studies conducted by TVA, the following quantities of marketable nonfuel products will be available for purchase from the 3,000 ton-per-day processing plant. These quantities are based on TVA's best estimates but are not guaranteed.

Schedule I		Est. Tons (2,000 lbs.) Available Per Year from The Processing Plant (300-day Operation)
Ferrous Metals	11%	99,000
Glass	15%	135,000
Mixed Nonferrous Metal including aluminum cans	1.5%	13,500
Aluminum Cans	0.5%	4,500

Schedule II	Percentage by Weight of Incoming Refuse	% by Wt. Unsegre. Hv. Fract.	Est. Ton (2,000 lb.) Available Per Yr. from The Processing Plant (300-day Operation)
Unsegregated Heavy Fraction			
Ferrous Metals	11%	22%	99,000
Glass	15%	30%	135,000
Nonferrous Metals	1.5%	3%	13,500
Other - Heavy Combustible Organic & Inorganic Materials	22.5%	45%	202,500
Totals	50%	100%	450,000

IV. Bidding Criteria - Schedule I

Separate bids should be submitted for each marketable product from the plant. The contract awards shall be made to the qualifying bidder offering the highest acceptable bid or percentage of published price as applicable for each product as specified on the bid form.

Ferrous Metals--This bid is for 100 percent of the ferrous metals extracted from the waste stream in TVA's processing plant for 10 years with two additional 5-year options by mutual agreement. The initial contract term shall begin with full commercial operation of the TVA processing facility. TVA guarantees a minimum of 35,000 tons (2,000 lbs. per ton) per year and the bidder must agree to purchase as much as 100,000 tons per year.

Bidder is required to:

A. Bid on percentage basis on #1 dealer bundle Birmingham market (high side only) as published by Iron Age magazine. Price to be set at the end of each month by the weekly average for the issues in that month f.o.b. TVA processing plant. The payment to TVA will be based on total tons (2,000 lbs. per ton) actually shipped from TVA's facility. Nonferrous tramp (refer to quality of product mix shown) will be included with the ferrous material shipped and should be considered in the percentage offered. There will be no adjustments for the tramp material included in the shipment.

Example:

Bidder offers 30 percent of #1 dealer bundle. Assume a monthly average price index of $60 and total monthly shipments of 8,000 tons (2,000 lbs. per ton). Thirty percent of $60 equals $18/ton times 8,000 tons/month equals $144,000 payment to TVA for that month's ferrous shipments.

B. Design and supply the ferrous metal separation system equipment. The design must be acceptable to TVA based on the equipment acceptability criteria listed below. TVA or its duly authorized agent will be responsible for installation, operation, and daily maintenance. Contractor will be responsible for major repairs and replacements. Contractor is required to guarantee his separation equipment's efficiency of removal subject to adjustment for loss of available ferrous below the guaranteed level. For example, an 85 percent guarantee as compared with an 80 percent guarantee results in a 5 percent greater payment to TVA. TVA will evaluate by multiplying bid and guaranteed efficiency. Performance will be tested by running 25 to 30 tons of normal incoming solid waste through the system and recording the weight of the retrieved ferrous metal from that quantity run. The material (previously run solid waste) shall then be rerun through the same system, making certain that four inches in burden depth is not exceeded on the conveyer into the separation system. The weight of the ferrous material retrieved in the first run shall not be less than the percent guaranteed in the contractor's bid proposal of the total metal reclaimed in both runs.

After a 3-month tuneup period, if the Contractor does not achieve his guaranteed efficiency, he will be required to pay the contract price for the ferrous lost until the efficiency is corrected. The above efficiency test will be conducted until the guaranteed percent is achieved. Testing will be performed bimonthly as a joint effort between TVA and Contractor.

Equipment Acceptability Criteria--Equipment reliability shall be judged on the basis of proven equipment performance and technical evaluation by TVA. Daily maintenance and operating requirements shall be judged on the basis of proven performance and technical evaluation of the system by TVA. Upon the expiration of this contract, TVA reserves the right to purchase the contractor-owned, ferrous-recovery system at a fair market price.

Glass--Contract award shall be to that bidder offering the highest price per ton for the clean mixed-color glass cullet. Such price is to be held firm for a 5-year period beginning with commercial operation of the plant. TVA guarantees a minimum quantity of 50,000 tons (2,000 lbs. per ton) per year.

Mixed Nonferrous--The contract award shall be to that bidder offering the highest percentage of the published selling price as published by *American Metal Market* newspaper for metals actually derived from the nonferrous product. Price to be set at the end of each month by the daily average for the issues in that month. Such price percentage will apply to each constituent metal which is to be determined by bidder's assay, according to standard business practice. TVA reserves the right to review any of Contractor's records relating to this product. TVA guarantees a minimum quantity of 5,000 tons (2,000 lbs. per ton) per year.

Two bids should be made under this item. One would be for the total nonferrous product including aluminum cans, the other for the nonferrous product excluding aluminum cans. These bids shall be firm based on percentage for a 10-year period beginning with commercial operation of the TVA plant.

Aluminum Cans--If TVA elects to award a contract for this product, the contract award shall be to that bidder offering the highest percentage of the value of 99.5 ingot as publised by *American Metal Market* newspaper. The first issue of each month sets the price for the entire month. This bid shall be firm based on percentage for a 5-year period beginning with commercial operation of the TVA plant. TVA guarantees a minimum quantity of 1,500 tons (2,000 lbs. per ton) per year.

Light Fraction Fuel Product--The contract award shall be to that bidder offering the highest price per ton (2,000 lbs. per ton) offered two ways (1) with primary shredding and (2) with secondary shredding. Bid to be firm for 10-year period beginning with full commercial operation of the TVA processing plant.

V. Bidding Criteria--Schedule II

Separate bids should be submitted for each marketable product from the plant. The contract awards shall be made to the qualifying bidder offering the highest acceptable bid as specified on the bid form.

Unsegregated Heavy Fraction (Contains all material other than light fuel fraction removed--The contract award shall be to that bidder offering the highest acceptable bid per ton (2,000 lbs. per ton). Bid to be firm for 10-year period beginning with full commercial operation of the plant.

Light Fraction Fuel Product--The contract award shall be to that bidder offering the highest acceptable bid per ton (2,000 lbs. per ton) offered three ways (1) with no shredding, (2) with primary shredding, and (3) with secondary shredding. Bid to be firm for 10-year period beginning with full commercial operation of the plant.

CONDITIONS OF SALE

1. Inspection. Because of the unusual nature of the proposed product offered and the unusual circumstances involved in producing the products, no product will be available for inspection at time of bidding. However, bidders are urged to inspect the premises of other solid waste processing plants now in operation. There is no guarantee that TVA's plant will be similar in every respect.

2. Description and Condition of Marketable Products. The ferrous metals, mixed nonferrous, and light fraction fuel products are offered without any quality guarantees. The aluminum can and froth-floated glass products are offered with product quality guarantees. No claims or allowances will be considered for recission of the sale or reduction of the purchase price unless TVA fails to meet its minimum product specification, which is offered only on the froth-floated glass and aluminum can product. THE PRODUCTS OFFERED FOR SALE HEREIN ARE OFFERED WITHOUT IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

3. Acceptance and Rejection of Bids. All bids must be in writing on the forms provided. TVA reserves the right to reject any or all bids, to waive defects in bids, to adjourn the time of opening bids by notice before or at the stated time of opening, and to withdraw any product from sale before acceptance of any bids. Bids by telephone or telegraph will not be considered. Modification by telegram or letter of bids already submitted will be considered if received before the time set for opening. Unless otherwise provided, bids must be submitted on the basis of the units stated on the bid form.

4. Withdrawal of Bids. Bids may not be withdrawn after bid opening without the consent of the contracting officer.

5. Award Criteria. If acceptable bids are received and TVA follows its proposed plans, contracts shall be awarded no later than June 1, 1976. TVA plans to make awards by item either on Schedule I or II but not both schedules. TVA reserves the right to determine and award the schedule most advantageous to TVA.

6. Payment. The payment due TVA by the Contractor shall be determined on all items (except Item 3, Schedule I) by the bid price per pound, ton, or percentage of published price as outlined on the bid form times the actual pounds or tons delivered. The payment for Item 3, Schedule I shall be determined after pickup of the product by the Contractor from his assay or sales receipt of quantities of each constituent metal times the percentage bid of the published price as outlined on the bid form. The Contractor shall be required to submit assay reports, sales receipts, and scale weights as applicable for each product within fifteen (15) days from receipt of the products to: Edward P. Bales, 144 Evans Building, Knoxville, Tennessee, for verification so a monthly billing may be made by

our accounting office. Payments shall be due within ten (10) days from receipt of invoice from TVA, and if these payments are not received within the specified time, a penalty of 1% shall be applied for each 30-day period or fraction thereof.

The payment in full amount shall be by cash, certified or cashier's check made payable to Tennessee Valley Authority and delivered to C. C. Irwin, Jr., Treasurer, 101 Old Post Office Building, Knoxville, Tennessee 37902.

7. Title, Risk of Loss, and TVA Liability. Risk of loss shifts to the Contractor after material is loaded on the Contractor's conveyance or Contractor's designated conveyance. The tital shall not vest in the Contractor until both loading and payment are completed.

8. Quantity and Weight. Estimates of quantity or weight of the various products as shown on the bid forms are only for the general guidance of bidders. Any discrepancies between quantity or weight will not affect the validity of the purchase agreement or be considered a basis for a claim. Contractor will be required to pay the unit price bid times the actual quantity or weight or the product lot. All contracts except the 500 tons per day of light fraction are for the entire output of the plant, less such amounts as TVA may retain for testing or other research or development purposes.

9. Release and Removal of Property. Unless otherwise permitted by TVA, the property purchased shall be removed from TVA premises within 5 calendar days after material is available for shipment. No release will be made on Sundays, holidays, or during other than regularly scheduled work hours. The Contractor will be notified by TVA when the property is ready for pickup or shipment. The Contractor shall reimburse TVA for any damage to TVA property or injury to TVA personnel (including death) caused by his removal operations. If the Contractor fails to remove the property within the specified time, TVA shall have the right to assess the Contractor a reasonable storage charge if the property is stored on premises owned or controlled by TVA, or store the property elsewhere for the Contractor's account. All costs incident to such storing, including handling and moving charges, shall be paid by the Contractor. Any details regarding removal of the property not already provided for shall be arranged with the Contracting Officer and shall be in writing. TVA will release property to designated third persons upon receipt of instructions in writing from the original Contractor. The Contractor is invited to have a representative present to witness the checking, measuring, or weighing of the property as no claims involving shortages or other discrepancies will be allowed after release or removal.

10. Shipping. Products offered for sale will be f.o.b. TVA's waste processing plant. TVA will load as required by Contractor for shipment within theContinental United States. TVA will not arrange for or package, crate, or otherwise prepare for export shipment. The bidder is required to state on his bid his proposed method of removal.

11. Weighing. Since weighing is necessary to determine the basis for payment, certified weighing shall be provided under the supervision of TVA. TVA approved weighing shall govern payment, but the Contractor is invited to witness and verify the weighing.

12. Changes. No changes in or modifications of this contract are effective or binding by TVA unless signed by the Contracting Officer.

13. Contingent Fees. The Contractor warrants that no person or agency has been employed or retained to solicit or secure this contract upon agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial agencies maintained by the Contractor for the purpose of securing business. For breach or violation of this contract, TVA shall have the right to annul this contract without liability or in its discretion to require the Contractor to pay in addition to the contract price or consideration, the full amount of such commission, percentage, brokerage, or contingent fee.

14. Persons Not to Benefit. No member of or delegate to Congress, or resident commissioner, or any officer or agent of TVA shall be admitted to any share or part of this contract or to any benefit that may arise therefrom unless it be made with a corporation for its general benefit. No award will be made directly or indirectly to any person employed by TVA whose duties involve the handling of the property and/or the records from which lists of property to be offered for sale are prepared, or who has the responsibility of receiving and opening bids, or making awards. A bid by or upon behalf of a TVA employee will not be recognized unless the bidder declares that it is by or upon behalf of a TVA employee and that such employee desires the property for his personal use and not for speculative resale. TVA may impose quantity or other appropriate restrictions on property that may be sold to a TVA employee.

15. Discrimination on the Basis of Age. Executive Order 11141 states that it is the policy of the Executive Branch of the United States that (1) contractors or subcontractors engaged in the performance of Federal contracts shall not, in connection with the employment, advancement, or discharge of employees, or in connection with the terms, conditions, or privileges of their employment, discriminate against persons because of their age upon the basis of a bona fide

occupational qualification, retirement plan, or statutory requirement, and (2) that contractors and subcontractors, or persons acting on their behalf, shall not specify in solicitations or advertisements for employees to work on Government contracts, a maximum age limit for such employment unless the specified maximum age limit is based upon a bona fide occupational qualification, retirement plan, or statutory requirement.

16. Indemnity. The Contractor shall be an independent Contractor for all purposes of this contract, and all persons engaged in carrying out any of the Contractor's obligations hereunder shall be the servants of the Contractor or its subcontractors and not the servants or agents of TVA. The Contractor is aware of the general location, nature and hazards of the work covered by this contract. The Contractor releases TVA, its agents and employees from all liability for Contractor's personal injuries, property damage, or loss of life or property arising out of or in any way connected with the performance of this contract. The Contractor will indemnify TVA, its agents and employees and save each of them harmless from any and all liability to Contractor's employees or any other third parties for personal injuries, property damage, or loss of life or property resulting from or in any way connected with the performance of this contract; provided, however, that the foregoing indeminification shall not apply to injuries or damages to persons or property the proximate cause of which is the sole negligence of TVA, its agents or employees. In any action by TVA to enforce this indemnity provision, the issue of whether injuries, damages, or losses were proximately caused by the sole negligence of TVA shall be tried de novo, and no judgment, pleading, or any other matter connected with any other action for such injuries, damages or losses shall be admissible against TVA in any such action.

The Contractor shall defend and save harmless TVA from all claims for material furnished or work done; shall promptly discharge the same and not suffer any mechanics or other liens to remain outstanding against any of the property used in connection with the work; and shall, on request, furnish satisfactory evidence that all persons who have done work or furnished materials have been fully paid.

TVA reserves the right to withhold from any sums due the Contractor sufficient sums to satisfy all such claims described in the preceding paragraphs and to adjust and to pay the same upon a fair and reasonable basis out of such funds so withheld should the Contractor, after written notice from TVA, fail to satisfy the same promptly.

17. Disputes. Any dispute arising out of or connected in any way with any obligation of the parties arising out of the performance or nonperformance of the contract whether arising before or after completion of performance, including disputes as to any alleged violation or breach thereof, which is not settled or disposed of by agreement of the parties shall be decided by the Contracting Officer on the basis of the contract file and any other facts which he may deem pertinent. The Contracting Officer shall reduce his decision to writing and promptly mail or otherwise furnish a copy thereof to the Contractor. Within thirty (30) calendar days from the receipt of such copy, the Contractor may appeal by mailing or otherwise furnishing to the Contracting Officer a written appeal addressed to TVA's General Manager. After the filing of such an appeal the General Manager or a representative or representatives designated by him shall conduct a hearing at which both TVA and the Contractor shall be afforded an opportunity to be heard and to offer evidence relating to the dispute. The General Manager or his representative or representatives shall arrive at a decision upon the basis of the evidence presented at the hearing.

    The decision of the General Manager or his representative or representatives shall be final and conclusive upon the parties except on questions of law or unless determined by a court of competent jurisdiction to have been fraudulent or capricious or arbitrary or so grossly erroneous as necessarily to imply bad faith, or not supported by substantial evidence; provided, that until such time as an appeal is taken to the General Manager and he (or his representative or representatives) renders a decision, the decision of the Contracting Officer shall govern the respective rights and obligations of the parties as to the matter in dispute and the Contractor shall proceed diligently with the performance of the contract in accordance with said decision; and provided further, that if no appeal to the General Manager is made within the time and in the manner prescribed above, the decision of the Contracting Officer shall be final and conclusive upon the parties.

18. Contracting Officer. The Contracting Officer shall be the Director of Purchasing, TVA, or his duly authorized representative. Except for decisions on disputes under the provision entitled DISPUTES, the Director of Purchasing has designated the Property and Supply Officer who administers this contract for TVA as his duly authorized representative to act as the Contracting Officer for all purposes in the administration of this contract, such designation to continue until revoked or modified by the Director of Purchasing. Copies of all correspondence and notices of Contractor relating to this contract and its performance shall be furnished to the Contracting Officer.

19. Correspondence. Copies of all correspondence relative to this invitation should be sent to Surplus Property Unit, Tennessee Valley Authority, Chattanooga, Tennessee 37401.

20. Termination. The Contracting Officer may, by written notice to the Contractor, terminate this contract in while or in part at any time, whenever the Contracting Officer shall determine that such termination is in the best interest of TVA. Upon termination, neither Contractor nor TVA shall have any further obligation under the contract, except for obligations which have accrued prior to termination. If Contractor has furnished the ferrous metal separation system equipment under Item 1 of Schedule I, TVA shall be responsible for removing such equipment and loading it for shipment on Contractor's conveyance at the waste processing plant.

21. Force Majeure. If, in the opinion of the Contracting Officer, either TVA or Contractor is unable to perform fully or in part its obligations hereunder as a result of a force majeure, it shall give the other party notice within ten (10) days and the time for performance of such obligations shall be extended by the Contracting Officer when, in his judgment, the facts justify such an extension. The term "force majeure" as employed herein shall mean acts of God, floods, strikes, accidents, or any other cause beyond a party's control and not due to its own negligence.

22. Term of Contract. The term of each contract shall expire 5 or 10 years from date of full commercial operation of the plant as applicable for each item. However, the contracts may be extended by mutual agreement for 5-year periods not to exceed 10 years beyond the original expiration date. TVA reserves the right to extend the contract or readvertise for bids for the new term.

23. Comparison of Bids. After the bids have been analyzed and if deemed acceptable, TVA may at its option request any bidder to submit a financial statement for review before awards are made.

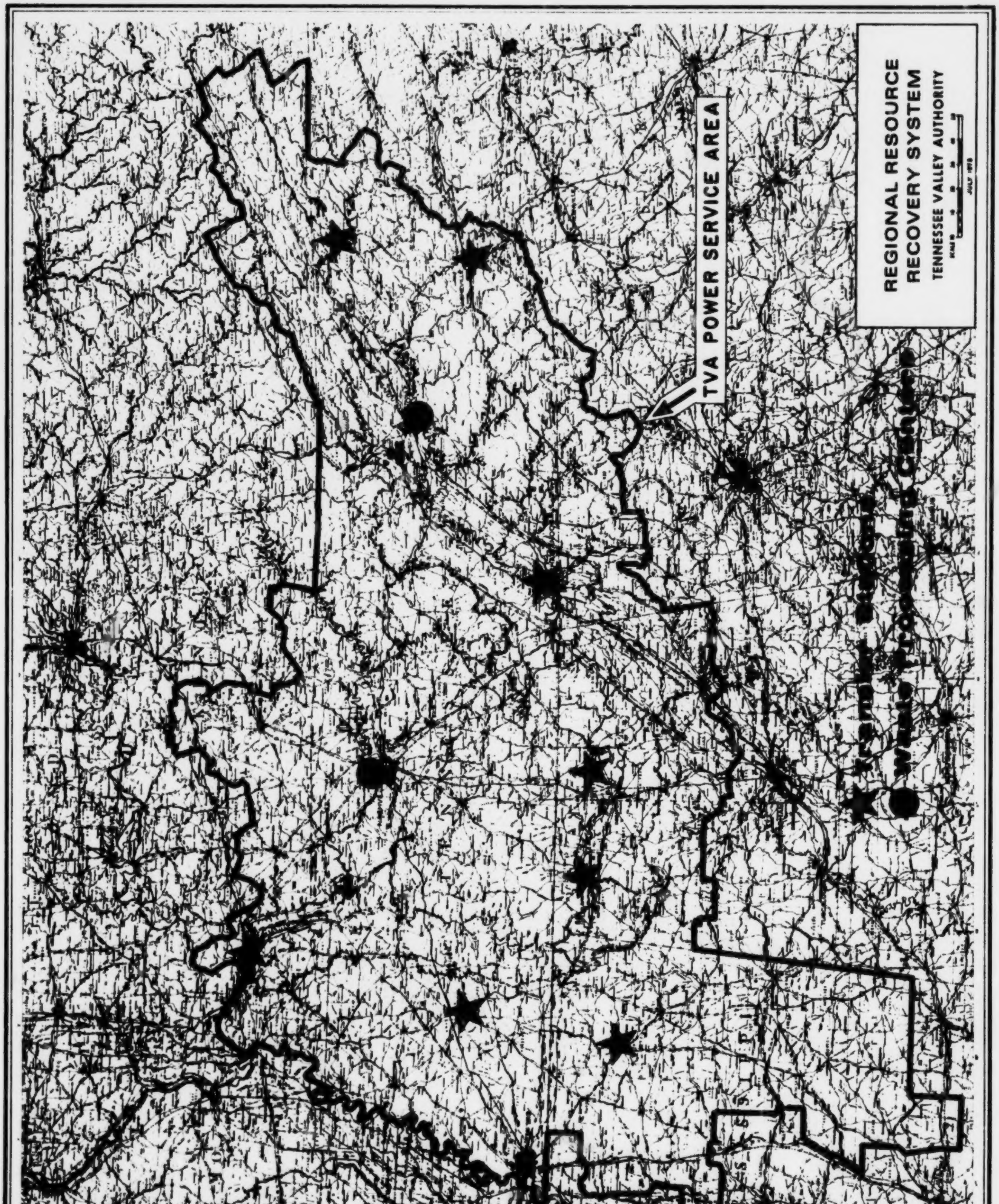
    In considering bids, TVA may consider bidder's bid price, organizational and financial capability, process efficiency reliability, and experience in dealing with processing and marketing the solid waste-derived product or a similar product being bid. It will be the bidder's responsibility to provide additional data when requested by TVA.

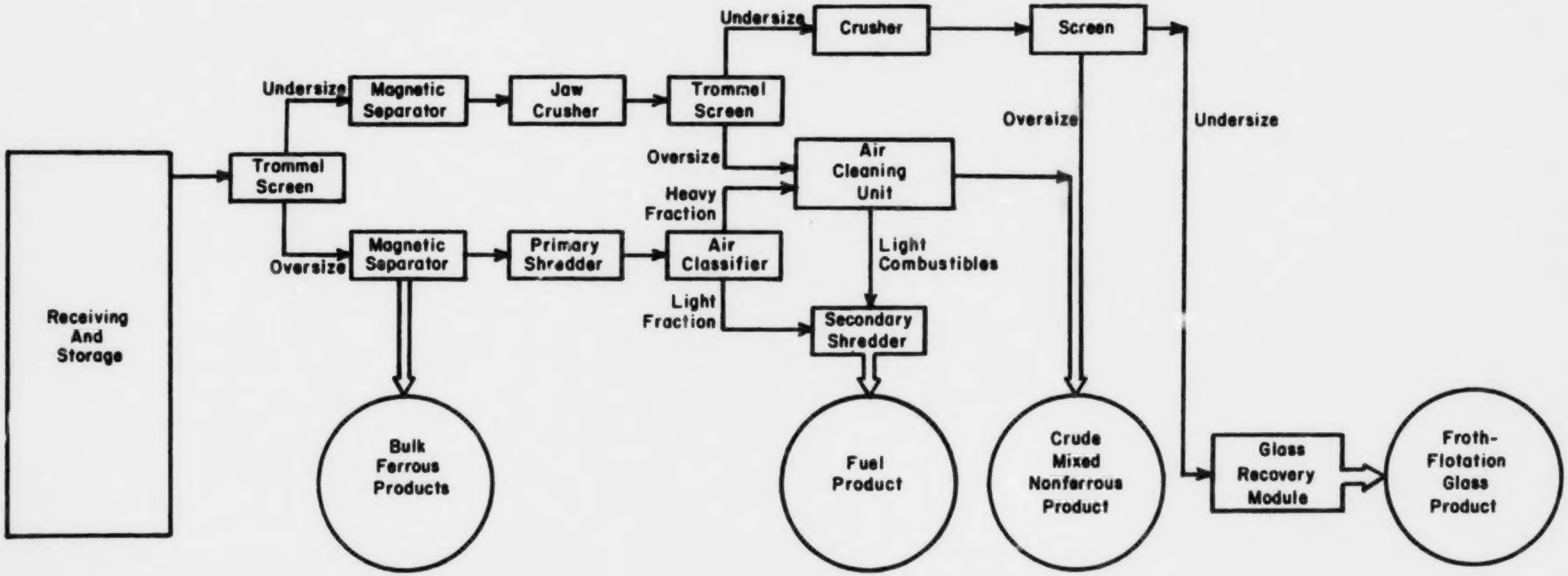
24. Performance Bond Commitment. As stated in the Conditions of Sale, Performance Bond, TVA requires a performance bond on this contract. Contractor's ability to furnish such a bond will be a positive factor in TVA's evaluation of bids. Each bidder shall submit with his bid a letter from an authorized representative of an acceptable bonding company. This should state that in the event the bidder receives an award the bonding company will make suitable bond. Bids not accompanied by this commitment may be rejected as nonresponsive.

25. Performance Bond. The Contractor shall be required to execute TVA's form of performance bond in the amount of $1,000,000 with surety satisfactory to TVA within ten (10) calendar days after the prescribed forms are presented for signature.

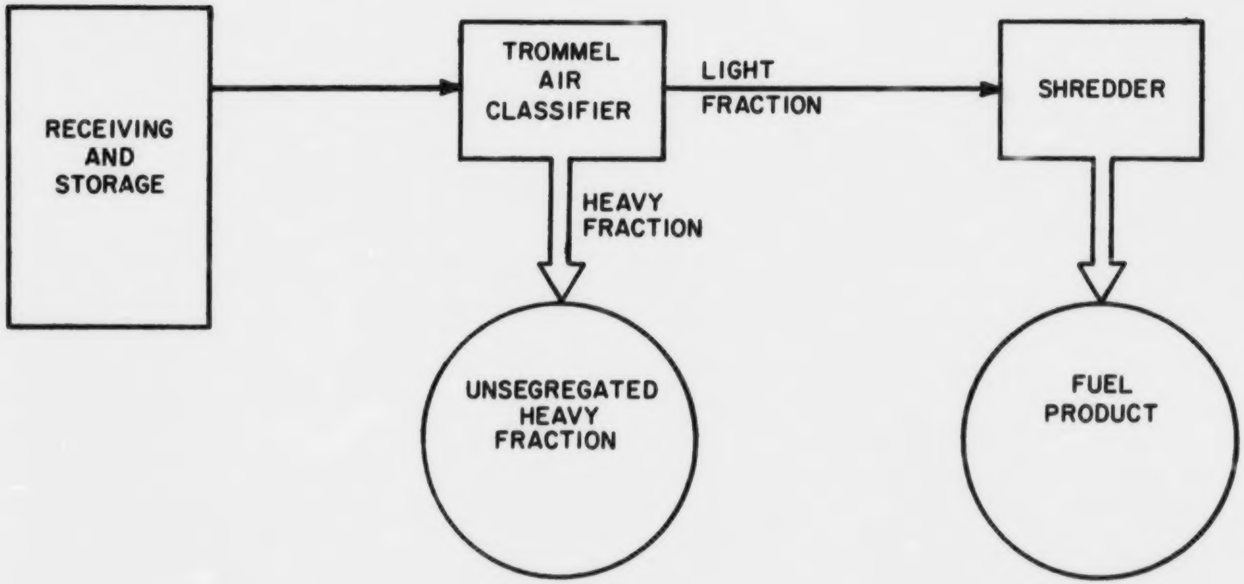
26. Additional Services. Any additional services performed by TVA at Contractor's request not covered by this contract shall be charged to the Contractor at cost plus the usual overhead.

27. Tennessee Sales Tax. Tennessee sales tax of three and one-half percent (3-1/2%) will be assessed on the full amount of purchase price unless exemption is claimed by correctly filling in, signing, and returning the attached exemption certificate with your bid.


REGIONAL RESOURCE
RECOVERY SYSTEM
TENNESSEE VALLEY AUTHORITY
TVA POWER SERVICE AREA


Receiving
And
Storage
Trommel Screen
Undersize
Oversize
Magnetic Separator
Magnetic Separator
Jaw Crusher
Primary Shredder
Trommel Screen
Undersize
Oversize
Heavy Fraction
Air Classifier
Light Fraction
Crusher
Air Cleaning Unit
Light Combustibles
Secondary Shredder
Screen
Oversize
Undersize
Bulk Ferrous Products
Fuel Product
Crude Mixed Nonferrous Product
Glass Recovery Module
Froth-Flotation Glass Product

TYPICAL PROCESSING LINE FOR SCHEDULE I
WASTE PROCESSING PLANT
CAPACITY PER LINE - 1000 TONS PER DAY
2 SHIFT OPERATION


RECEIVING AND STORAGE
TROMMEL AIR CLASSIFIER
LIGHT FRACTION
SHREDDER
HEAVY FRACTION
UNSEGREGATED HEAVY FRACTION
FUEL PRODUCT

TYPICAL PROCESSING LINE FOR SCHEDULE II
WASTE PROCESSING PLANT
CAPACITY PER LINE - 1000 TONS PER DAY
2 SHIFT OPERATION

Appendix 2

SPECIFICATION FOR NONCOLOR SORTED GLASS FINES

1. SCREEN SIZING: 0% retained on 2-inch mesh screen
   10% maximum through 140 mesh screen

2. COLOR: Fines to contain only soda lime glass. No color mix specified.

3. LIQUID: No drainage from representative sample. Should be noncaking and free flowing.

4. ORGANIC MATERIAL: Total paper, plastics and organic materials maximum 0.25%

5. MAGNETIC METAL: .05% maximum
   .25 inch maximum size

6. NONMAGNETIC METAL:

SIZE	NO. PARTICLES
+20 mesh	1 particle in 40 lbs. (max. size 0.25 inch)

7. SOLID INORGANIC OTHER THAN METAL:

   7.1 TOTAL INORGANIC AMOUNT: Max. 0.10% (nonrefractory)
   SIZE: Max. 0.25 inch

   7.2 REFRACTORY

SIZE	NO. PARTICLES
+20 mesh	1 particle in 40 lbs. (Max. size 0.25 inch)
-20+40 mesh	2 particles in 1 lb.
-40+60 mesh	20 particles in 1 lb.

Special note: This product will be from flotation and size reduction processes where nonmagnetic metals and refractory particles will have been removed.

Appendix 3

SPECIFICATIONS FOR ALUMINUM SCRAP

1. Fines. All scrap material tendered will not contain more than 1% - 12 mesh (U.S. standard).

2. Organics Other Than Coatings. All scrap material tendered will not contain more than 2% organics other than coatings.

3. Chemical Analysis. All scrap material tendered when melted (without any additional separation) will have a chemical analysis which conforms to one of the two grades set forth in the following tables:

GRADE I

Element	Maximum % by Weight
Si	.30
Fe	.70
Cu	.40
Mn	1.50
Mg	2.00
Cr	.10
Zn	.25
Ti	.08
Pb	.04
Sn	.04
Others	
Each	.04
Total	.12
Remainder - Aluminum	

GRADE II

Si	1.00
Fe	1.00
Cu	2.00
Mn	1.50
Mg	2.00
Cr	.30
Zn	2.00
Ti	.30
Pb	.50
Sn	.30
Others	
Each	.04
Total	.12
Remainder - Aluminum	

SALES CONTRACT SCHEDULE

Invitation No. 42-3166
Page No. 1

Item No.	ARTICLES
	The items listed consisting of fuel products, valuable metals, glass and other marketable products derived from a solid waste processing plant are offered for sale and are scheduled to be available for delivery no later than January 1, 1980. For review of drawings or engineering studies of the proposed plant or additional test or survey information, see Edward P. Bales, 144 Evans Building, Knoxville, Tennessee, telephone area code 615-637-0101, extension 2913.
	These items shall be offered f.o.b. TVA's waste processing plant, and the bidder is required to show on bid form the method of transportation he plans to use.
	Two schedules are proposed as outlined in the general information shown.
	Note: Requirements for a performance bond and performance bond commitment are applicable to both Schedule I and II. Refer to Conditions of Sale Nos. 24 and 25.
	SCHEDULE I - All Ferrous Metals (includes bulk and other ferrous scrap)
	(See General Information - II and III. Quality and Quantity of Marketable Products and IV. Bidding Criteria - Ferrous Metals) Note: Bidder's attention is called to the special requirements applicable to this item.
1	Bid on percentage basis of #1 dealer bundle on Birmingham market (high side) as published by Iron Age magazine. Price to be set at the end of each month by the weekly average for the issue in that month. The percentage offered will be based on total tons (2,000 lbs. per ton) actually shipped from TVA's facility. Nonferrous tramp (refer to quality of product mix shown) will be included with the ferrous materials shipped and should be considered in the percentage offered. There will be no price adjustment for the tramp material included in shipment. F.o.b. TVA's waste processing plant. (Bidder to supply ferrous metal separation equipment for this item.) ____% per Ton (2,000 lbs.) of published price
	Bidder's percentage guarantee on efficiency of removal. ___%
	Bidder's proposed method of transportation______________________

SALES CONTRACT SCHEDULE

Invitation No. 42-3166
Page No. 2

Item No.	ARTICLES

SCHEDULE I - Mixed-Color, Froth-Flotation Glass

(See General Information - II and III. Quality and Quantity of Marketable Products and IV. Bidding Criteria)

2 Bid on price per ton. (Bid to be firm for 5-year period beginning with full commercial operation o TVA processing plant). F.o.b. TVA's waste processing plant. $____per Ton (2,000 lb.)

Bidder's proposed method of transportation ____________________

SCHEDULE I - Mixed Nonferrous Metal With or Without Aluminum Cans

(See General Information - II and III. Quality and Quantity of Marketable Products and IV. Bidding Criteria)

3 Bid on percentage basis of the published selling price as published by American Metal Market newspaper for metals actually derived from the nonferrous product. Price to be set at the end of each month by the daily average for the issue in that month. Such price percentage to apply to each constituent metal sold by bidder and such percentage to be determined by bidder's assay, with full audit and inspection rights to be retained by TVA. F.o.b. TVA's waste processing plant.

A. With aluminum cans ____% per Ton (2,000 lb.) of published price

B. Without aluminum cans ____% per Ton (2,000 lb.) of published price

Bidder's proposed method of transportation ____________________

SALES CONTRACT SCHEDULE

Invitation No. 42-3166
Page No. 3

Item No.	ARTICLES

SCHEDULE I - Aluminum Cans

(See General Information - II and III. Quality and Quantity of Marketable Products, Iv. Bidding Criteria and Appendix 3)

4 Bid on percentage basis of price for 99.5 ingot as published by American Metal Market newspaper (Bid to be firm for a 5-year period beginning with full commercial operation of the TVA processing plant). F.o.b. TVA's waste processing plant.

A. Grade I (as shown in Appendix 3)	____% per pound of published price
B. Grade II (as shown in Appendix 3)	____% per pound of published price

Bidder's proposed method of transportation ______________________________

SCHEDULE I - Light Fraction Fuel Product

(See General Information - II and III. Quality and Quantity of Marketable Products and Iv. Bidding Criteria)

5 Bid price per ton to be firm for 10-year period beginning with full commercial operation of the TVA processing plant. F.o.b. TVA's waste processing plant.

A. With primary shredding	$_____ per Ton (2,000 lb.)
B. With secondary shredding	$_____ per Ton (2,000 lb.)

Bidder's proposed method of transportation ______________________________

SALES CONTRACT SCHEDULE

Invitation No. 42-3166
Page No. 4

Item No.	ARTICLES	
	SCHEDULE II - Unsegregated Heavy Fraction (Contains all material other than light fuel fraction removed)	
	(See General Information - II and III. Quality and Quantity of Marketable Products and V. Bidding Criteria)	
6	Bid price per ton to be firm for 10-year period beginning with full commercial operation of the TVA processing plant. F.o.b. TVA's waste processing plant.	$_____ per Ton (2,000 lb
	Bidder's proposed method of transportation ________________________	
	SCHEDULE II - Light Fraction Fuel Product	
	(See General Information - II and III. Quality and Quantity of Marketable Products and V. Bidding Criteria)	
7	Bid price per ton to be firm for 10-year period beginning with full commercial operation of the TVA processing plant. F.o.b. TVA's waste processing plant.	
	A. With no shredding	$____ per Ton (2,000 lb.)
	B. With primary shredding	$____ per Ton (2,000 lb.)
	C. With secondary shredding	$____ per Ton (2,000 lb.)
	Bidder's proposed method of transportation ________________________	

TENNESSEE RETAIL SALES TAX

TVA will collect for the State of Tennessee the Sales tax of four and one-half percentum (4-1/2%) imposed by Chapter 3 of the Public Acts of Tennessee, 1947, as amended, on all sales of goods made pursuant to this invitation unless the transaction is exempt from the tax under the provisions of said act or the regulations issued by the State Commissioner of Finance and Taxation pursuant thereto. Transactions exempt from the tax are:

1. Sales of goods which are to be consigned for delivery by common or contract carrier to destinations outside the State of Tennessee and are not intended for use in said state.
2. Sales of goods to the State of Tennessee or any county or municipality thereof, or to any agency of the Federal Government.
3. Sales of goods to retailers, merchants, jobbers, dealers, or others for resale in the State of Tennessee.
4. Sales of raw materials to be used in future processing, manufacturing or conversion into articles of tangible personal property for resale where such materials become a component part of the finished product or are used directly in fabricating, converting or processing the same.
5. Sales of materials or equipment which are to be used by the buyer (or subcontractor) for construction of or installation in an electric generating plant or distribution system owned or operated by the United States, or any agency thereof created by act of Congress, or by the State of Tennessee, or any agency or political subdivision thereof, or by any authority organized pursuant to the Tennessee Electric Membership Corporation or Electric Cooperative Acts.

The price or prices inserted by bidders in the appropriate blanks shall not include the tax. If the bidder is awarded a contract for any part of the goods covered by this invitation to bid he shall include the 4-1/2% tax when payment for the goods is made, or if the transaction is exempt from the tax he shall furnish TVA a certificate showing the reason for the exemption. If the purchase by the bidder of goods covered by this invitation is exempt from the tax the bidder shall complete the following certificate:

EXEMPTION CERTIFICATE

I certify that the purchase by me of any part of the goods covered by this invitation is exempt from the Tennessee Retail Sales Tax by reason of facts covered in paragraph numbered __ above (include number of one of the five paragraphs above which set out the basis of exemption.)

____
Bidder's name - print or type

By ________________________
Sign - DO NOT PRINT

NOTE
If certificate is not completed by inserting one or more of the above numbered exemption paragraphs in the space provided and signed, same as signature on bid, the sales tax will be collected from the bidder in the event an award is made to him.

TVA 5028 (DP-6-71)

SECTION IX

POWER PLANT MODIFICATIONS

I. Introduction

This section of the report defines a conceptual design and provides cost estimates for receiving, storing, and transporting refuse-derived fuel for use as an auxiliary fuel source in Kingston units 5-9, Cumberland units 1-2, Bull Run, and Colbert units 1-4.

The design and cost estimates in this section are the result of the combined efforts of Combustion Engineering, Inc., of Windsor, Connecticut, and the architectural, civil design, civil engineering, electrical engineering, electrical design, mechanical engineering, mechanical design branches, and the costs and estimating staff of DED. Various equipment vendors were also quite helpful in this design and estimating study.

The objective of this study is to obtain a design for which refuse-derived fuel is unloaded, handled, stored at 2,000-ton capacity, and injected into fossil fuel steam generators as an auxiliary fuel at rates to provide up to 20 percent of the steam generator's maximum continuous rating (MCR) heat input.

As the study progressed, Bull Run Steam Plant emerged as the most economically attractive site at which to burn refuse-derived fuel. As a result of the status, studies of estimates for 1,000 and 500-ton capacity storage at 10 percent of the steam generator's MCR heat input were also completed. (The results of these studies and estimates will become an appendage to this 2,000-ton storage scheme report.)

II. Summary and Conclusions

The proposed power plant modifications are based on receiving, storing, and transporting refuse-derived fuel with the use of the current state-of-the-art equipment and operating techniques. Since much of the equipment would be included in the air and materials handling classification and are infrequently used in the electric utility industry, TVA relied upon resource recovery experienced vendor and consultant firms in determining the design criteria. The equipment sizes are based on the ability to supply a variable feed rate of from 0 to 20 percent of boiler MCR heat input using a 6,000 BTU/lb heat value for the refuse-derived fuel at each of the 4 steam plant locations.

The locations for the SWDF handling system were coordinated with Civil Engineering Branch of DED and avoided the prime locations for any cooling towers, flue gas scrubbers, or (except for Kingston site) one boiler unit that may possibly be constructed at some future date. Piping to the boilers was routed through the location for the possible future boiler unit at Bull Run and Colbert.

The power plant modifications include a paved area for unloadin and maneuvering 75 yd^3 transfer truck trailers, R.R. facilities for receiving "piggyback" transport of the truck trailers, forklift for unloading "piggyback" transport of truck trailers, and truck tractors for unloading trailers into receiving building hoppers. After the SWDF is unloaded into the receiving building hoppers via the transfer trailer hydraulic rams, the SWDF is transported from the hoppers to 4-500 ton storage silos via hopper traversing screw conveyors, belt conveyors, fluffing rolls, rotary airlock feeders, 18-inch positive displacement air blowers, 18-inch transport piping, and 18-inch transfer valves. From the storage silos, the SWDR is conveyed to the boiler furnaces via a silo sweep feed system, drag chain type outfeed conveyors, split flow discharge screw conveyors, fluffing rolls, metering belt conveyors, rotary airlock feeders, positive displacement air blowers, and transport piping. All the boiler charging equipment except for the blowers and piping are housed under the 81-foot diameter storage silos. The positive displacement blowers are housed in a separate blower building (ref: respective flow diagrams, drawings . . . GB-8RO, for system flow patterns).

Boiler furnace modifications are minor, particularly for the Combustion Engineering (CE) tangentially-fired boilers of Kingston and Bull Run. The CE boilers would be modified by installing one refuse transport pipe into the top secondary combustion air chamber of each corner burner arrangement (ref: drawings 00A689-GB-7ARO and 7BRO). The area remaining between the transport piping and the secondary air chamber walls would continue to be used for secondary combustion air. The wall-fired Babcock and Wilcox boilers of Colbert and Cumberland would need waterwall tubing modifications and would be located above the top row of wall burners or between the wall burner rows. The number of burners for the CE boilers was determined by the number of corner burner arrangements.

The number of burners for the B&W boilers was determined by maintaining the ration of $\frac{\text{LBS coal/coal pipe}}{\text{LBS refuse/refuse pipe}}$ at 10 percent heat input at approximately 1 and by maintaining $\frac{\text{Number coal pipes}}{\text{Number refuse pipes}}$ at approximately 5. These ratios are intended to ensure complete combustion of refuse and are based on the Union Electric Meramec system design.

The total estimated costs in 1977 dollars for the four steam plant sites' modifications are as follows:

Kingston units 5-9	$30,000,000
Cumberland units 1-2	36,000,000
Colbert units 1-4	29,000,000
Bull Run	25,000,000

These costs include materials, labor, construction facilities, design, interest during construction, and various other labor support items (see Table 9-1). Estimates were also made for Bull Run Steam Plant utilizing 1,000 and 500 ton storage capacities at 10 percent of the steam generator's MCR heat input. Summaries of these two estimates are shown in Tables 9-2 and 9-3, respectively.

Boiler performance, I.D. and F.D. fan flows and ash emission rates will, of course, vary with the coal and refuse chemical compositions because their chemical compositions determine the LBS/HR of combustion air and LBS/HR of flue gas. In general, however, boiler efficiency is expected to drop by approximately 1 percent at 90 percent coal--10 percent refuse heat input rates and 2 percent at 80 percent coal--20 percent refuse as compared to the boiler heat input (BTU/HR) being supplied solely by coal at 100 percent of maximum continuous rating (MCR).

This decrease in furnace efficiency is caused primarily by the increase in moisture content of the combined refuse--coal fuel that is in turn caused by the high (25 percent) moisture content of the refuse derived fuel. The higher moisture content of the fuel would increase the latent heat H_2O losses in the flue gas. With this decrease in boiler efficiency, a higher coal and refuse rate (LBS/HR), thus heat input potential, would be required to produce the same heat available for steam generation. With the higher coal-refuse rate, a higher combustion air rate, higher dry flue gas rate, and higher dry flue gas heat loss would be present. There would also be a decrease in air preheater efficiency due to a higher flue gas rate and lower combustion air rate through the air heater. The lower combustion air rate through the air heater is the result of the transport air for charging refuse into the furnace being used as combustion air. This transport air does not pass through the air heater. Thus, the total efficiency drop of the boilers due to refuse combustion is the sum of the increases of the H_2O latent heat loss, higher flue gas rate, higher flue gas temperature, and lower air preheater efficiency. The H_2 content of the refuse is about that of coal (4-5 percent by weight). If the H_2 content of the refuse were to be lower than that of coal, then efficiency would not drop quite as significantly.

TABLE 9-1

POWER PLANT MODIFICATION COST ESTIMATE SUMMARY

	THOUSANDS OF DOLLARS			
	Kingston 5-9	Cumberland 1-2	Colbert 1-4	Bull Run 1
Yard Work	$ 300	$ 1,000	$ 1,800	$ 500
Structures	1,230	1,280	1,030	1,040
Furnace Entry Modifications	295	390	200	120
Powerhouse Modifications	55	60	50	40
Process Equipment	5,600	7,600	4,400	4,100
Storage Silos	4,000	5,000	4,300	4,300
Miscellaneous Equipment	700	700	700	700
Electrical Work	2,800	2,270	1,750	1,750
Subtotal	14,980	18,300	14,230	12,550
Construction Facilities	1,500	1,830	1,420	1,260
Total Direct Construction	16,480	20,130	15,650	13,810
Field General Expense	1,650	2,010	1,570	1,380
Contingency	3,430	4,115	3,480	2,695
Total Field Construction	21,560	26,255	20,700	17,885
Engineering Design	1,200	1,150	1,125	1,125
Manager's Office - OEDC	70	85	65	60
CSB - Engineering Group	20	20	20	20
Personnel	30	30	30	30
Purchasing	120	120	120	120
Medical Services	60	60	60	60
Employee Compensation Benefits	300	300	300	300
A&G	240	280	230	200
Interest During Construction	1,400	1,700	1,350	1,200
Total Project (1975 Dollars)	$ 25,000	$ 30,000	$ 24,000	$ 21,000
Escalated to 1977 Dollars	$ 30,000	$ 36,000	$ 29,000	$ 25,500

OEDC
Costs and Estimating Staff
September 9, 1975

TVA COST ESTIMATES 2000 TON STORAGE 20% REFUSE BURN

TABLE 9-2

COST ESTIMATE FOR MODIFICATION OF BULL RUN STEAM PLANT UTILIZING 1,000 TON STORAGE CAPACITY

		($000)
Yard Work	$	360
Structures		820
Furnace Entry Modifications		120
Powerhouse Modifications		40
Mechanical Equipment (Receiving Building)		730
Mechanical Equipment (Blower Building & Silos)		1,505
Ductwork		35
Ventilation		105
Process Piping		1,200
Storage Equipment		1,170
Miscellaneous Equipment		205
Electrical		1,710
Subtotal		8,000
Construction Facilities		800
Total Direct Construction		8,800
Field General Expense		880
Contingency		1,730
Total Field Construction		11,410
Engineering Design		1,125
Manager's Office - OEDC		40
CSB- Engineering Group		20
Personnel		25
Purchasing		100
Medical Services		50
Employee Compensation Benefits		300
A&G		130
Interest During Construction		800
Total Project (1975 Dollars)	$	14,000
Escalated to 1977 Dollars	$	17,000

OEDC
Costs and Estimating Staff
September 29, 1975

TABLE 9-3

COST ESTIMATE FOR MODIFICATION OF BULL RUN STEAM PLANT UTILIZING 500 TON STORAGE CAPACITY

	($000)
Yard Work	$ 360
Structures	615
Furnace Modifications	120
Powerhouse Modifications	40
Mechanical Equipment (Receiving Building)	365
Mechanical Equipment (Blower Building & Silos)	1,335
Ductwork	35
Ventilation	85
Process Piping	930
Storage Equipment	625
Miscellaneous Equipment	100
Electrical	1,620
Subtotal	6,230
Construction Facilities	630
Total Direct Construction	6,860
Field General Expense	690
Contingency	1,605
Total Field Construction	9,155
Engineering Design	1,100
Manager's Office - OEDC	30
CSB - Engineering Group	20
Personnel	25
Purchasing	90
Medical Services	45
Employee Compensation Benefits	280
A&G	110
Interest During Construction	645
Total Project (1975 Dollars)	$ 11,500
Escalated to 1977 Dollars	$ 14,000

OEDC
Costs and Estimating Staff
October 1, 1975

Ash emission rates from the furnace would also increase with coal-refuse combustion. TVA's highly refined refuse would contain 12-15 percent (by weight) with coal ash frequently being this high also. However, it takes about 1.85 pounds of 6,000 BTU for equivalent heat input of coal, so fly ash rates from the furnace (prior to ash collection devices) will increase about 4 to 7 percent at 10 percent refuse--90 percent coal and about 8 to 13 percent at 20 percent refuse--80 percent coal. These 4 to 7 percent and 8 to 13 percent ash emission rate increases from the furnace were based on a total incoming ash split of 80 percent fly ash--20 percent bottom ash for coal and coal refuse; the August 1975 coal heating values, plant heat rates, and coal ash contents for each respective plant of Kingston, Cumberland, Colbert, and Bull Run; and a 6,000 BTU/lb, 13.4 percent ash refuse derived fuel.

Bottom ash equipment capacities do not appear to be surpassed with 20 percent refuse combustion, but would be marginal at Colbert and Kingston.

Fly ash collection equipment performance is expected to decrease due to a higher flue gas flow rate and lower SO content. Ash resistivity would increase with these factors for these four plants. The gas temperature to the precipitators is expected to increase only 7°F at 10 percent heat input and 10°F at 20 percent heat input. The change in gas temperature should not significantly affect fly ash resistivity.

Burning combined fuel at the projected rate of 10 percent of the BTU input to the boiler may lower SO_2 and NO_x concentration (PPM or mg/l) in the stack gas but total NO_x emission in LBS/HR may increase due to the higher air and flue gas weights present during refuse--coal combined combustion. The NO_x is a function of maximum furnace temperature and excess O_2. The excess O_2 for combustion will remain at 20 percent and furnace temperatures (around firebox) may not change much. On a fuel basis of lower sulfur for refuse-coal combustion, the lower sulfur content is expected to be more significant than the increased gas weight, thus resulting in a decrease in total LBS/HR of SO_2 emitted from the stacks. This conclusion on SO_2 is based on a theoretical molal basis and is dependent only on fuel analysis. The coal and refuse analysis that was used yielded SO_2 drop of 7.7 percent for 10 percent refuse heat input and 16.1 percent for 20 percent refuse input. Using the same analysis, NO_x on total weight basis (LBS/HR) increases 1.57 percent at 10 percent and 3.0 percent at 20 percent. On a ppm, mg/l, or $\frac{\text{LB } SO_2}{\text{LB flue gas}}$ basis, the SO_2 should decrease 9.73 percent at 10 percent and 19.07 percent at 20 percent heat inputs using molal fuel basis for calculation.

I.D. and F.D. fan capacities are not expected to be exceeded due to combined refuse--coal combustion. The air flow (LBS/HR) to the F.D. fan is expected to decrease by 0.5 to 3 percent at 10 percent refuse--90 percent coal heat input and range from a 0.9 percent decrease to a 0.8 percent increase at 20 percent refuse--80 percent coal combination as compared to firing coal only. Data from CE indicates that F.D. fan horsepower will increase about 1.5 percent at 20 percent refuse--80 percent coal heat input for Kingston 5-9 as compared to its horsepower at 100 percent coal. At Kingston, CE predicts a 36 horsepower increase at 20 percent refuse--80 percent coal heat input; this is 2.6 percent of the 2 F.D. fan motors' horsepower. The gas weights to the Kingston and Colbert I.D. fans are expected to increase 1.8 to 2.4 percent at 10 percent refuse--90 percent coal heat input and 3.9 to 5.2 percent at 20 percent refuse--80 percent coal heat input. Data from CE indicates that I.D. fan horsepower will increase about 16.6 percent at 20 percent refuse--80 percent coal heat input for Kingston 5-9 compared to its horsepower at 100 percent coal, but the CE prediction of a 200 horsepower increase at 20 percent refuse--80 percent coal is only 5.7 percent of the 2 I.D. fan motors' horsepower.

With a 20 percent refuse--80 percent coal heat input, CE predicts a decrease of 378 horsepower for the coal pulverizers at Kingston 5-9.

Coal flow from mine to steam plant at the 4 steam plant sites will decrease about 8.8 to 9.0 percent at 10 percent refuse--90 percent coal heat input and about 18.0 percent at 20 percent refuse--80 percent coal heat input. The 1 percent and 2 percent drops in boiler efficiency are included in these coal flow reduction figures and are based on 6,000 BTU/lb refuse and the coal heating values used at the plants during August 1975.

III. Operating Manpower Requirements

The following is an estimate of the added manpower requirements for receiving and handling SWDF at a modified steam plant:

Job Classification (Rail Receiving Facility)	Manpower/Shift
* Two (2) Fork-Lift Operators	2
* Three (3) Tractor Drivers	3
Truck Receiving Facility	
One (1) Systems Operator	1
One (1) Superintendent	1
One (1) Maintenance	1
One (1) Laborer	1
Storage Silos and Blower Building	
One (1) Operator	1
Total Manpower/Shift	10

*Receiving one hundred (100 tons/hour)

IV. Summary of Solid Waste System Structures at Steam Plants

A. Access Roads and Railroads (reference drawings are available from DED).

1. Kingston

The existing railroad would be used at the Kingston site so no additional rail track was considered. No additional access roads would be needed (reference drawing 36-M-00N-689-GB-1R0).

2. Cumberland

A 2730' loop would be added to the existing railroad starting in the plant storage area on the southeast side of the powerhouse, circling to the top of the construction area hill on the east side of the powerhouse, and rejoining the existing railroad farther southeast of the powerhouse (reference drawing 46-M-00N-689-GB-1R0). A very short truck access road (400') to the receiving building area would also be provided (reference drawing 46-M-00N-689-GB-1R0). A storage area would have to be relocated to another area southeast of the construction area.

3. Colbert

An additional 2800' of railroad track would be added to the existing railroad starting at the track entering the switchyard on the southeast side of the powerhouse, diverting to the road between the powerhouse and control building, and ending on the southwest side of the powerhouse (reference drawing 37-M-00N-689-GB-1R0). The existing road that formerly was used as a construction access road on the south side of Cane Creek would be used but a new bridge across Cane Creek and a short section (1700') road would be built for the transfer trailer trucks (reference 37-M-00N-689-GB-1R0). A short road (300') from the north side of the powerhouse would also be built.

B. Truck Storage Area

A small amount of the cost of power plant modifications was for grading and paving a 400' x 450' storage area if it was decided to use transfer trailer trucks as storage. The cost of this was only about 0.7% (maximum) of the total cost of the modification on the Bull Run and Colbert plants. No truck storage was included on Kingston and Cumberland.

C. Railroad Receiving Facility (Gatehouse)

The railroad unloading area would be paved for the forklift to unload transfer trailers from flatbed railroad cars. A small gatehouse with provisions for plumbing, lighting, and communications would be provided for Kingston plant only.

D. Truck Receiving Facility (Receiving Building)

An area in front of the receiving building would be paved for truck maneuvering while preparing to back into the receiving building (reference drawing B689-GB-2R0).

The receiving building would be a two story (ground floor and basement) building which houses a small administrative and maintenance area, six receiving hoppers, various pieces of materials handling equipment, plumbing, lighting, communications, dust collecting equipment, and a fire protection system. Its area size would be 150' x 40' for all four steam plants.

E. Storage Silo

The storage silos would be above ground, round silos with, diminishing diameter as height increases. The sides of the silos would be carbon steel painted for rust proofing. The silo's floor would set 15-17' above the ground and would be 81' diameter (at ground level) and 53' high. With an assumed SWDF bulk density of 10 lb/ft^3, each silo would contain 500 tons of SWDF. In the floor of the silo or under the silo would be housed: a sweep feed drive system, outfeed conveyors, split flow discharge screws, fluffing rolls, weigh belt conveyors, air lock feeders, and transport piping. The silo sheel and size would be identical at all four steam plants.

F. Blower Building

The blower building would house the positive displacement blowers that blow refuse into the boiler furnaces. The building would have ventilation fans and would set on a concrete pad. The blower buildings for Colbert and Bull Run would house sixteen 10" blowers each with each building being 85' x 30'. The Cumberland and Kingston blower buildings would house thirty-two 12" blowers and forty 8" blowers, respectively; their dimensions would be 180' x 30' and 176' x 30', respectively.

G. Furnace Entrance Modifications

Furnace modifications for the Combustion Engineering boilers of Bull Run and Kingston would be very minor. The modifications would consist of installing refuse transport piping into the top secondary combustion air chamber above the top coal burner in every corner burner arrangement of the boiler furnaces (reference drawings 00A689-GB-7AR0, - 7BR0). The remaining area between the transport pipe and the air chamber walls would continue to be used for secondary combustion air. The number of boiler entrances and transport pipes was determined by the number of corner burner arrangements of the boiler. The Bull Run double-twin furnaces have sixteen corner burner firing arrangements, so sixteen separate refuse transport pipes and refuse burners would be used. The Kingston 5-9 twin furnaces have eight corner burner arrangements per boiler unit, so eight separate refuse transport pipes and burners would be used per unit.

Furnace modifications of the Babcock and Wilcox boilers of Cumberland and Colbert would involve some water wall tube modifications. The refuse transport piping would enter the boiler in a horizontal row(s) (as coal piping ones) at a location either above the top row of coal pipes or midway between the rows of coal pipes (reference drawing 00W689-GB-6R0). The number of refuse burners for the B&W furnaces were determined by keeping close to a ratio of $\frac{\text{1 lb coal/pipe}}{\text{lb refuse/pipe}}$ at 10% refuse heat input and a ratio of 5 coal pipes to produce even distribution. Cumberland would have ratios of $\frac{\text{0.87 lb coal/coal pipe}}{\text{lb refuse/refuse pipe}}$ and $\frac{\text{5.5 coal pipes}}{\text{1 refuse pipe}}$ at 10% refuse heat input. Colbert would have ratios of $\frac{\text{1.07 lb coal/coal pipe}}{\text{lb refuse/refuse pipe}}$ and $\frac{\text{4.5 coal pipes}}{\text{refuse pipe}}$.

Each transport pipe to the furnace would be joined to a reducer at the furnace windbox and the piping entering the furnace water wall would be larger than the transport pipe so that the velocity of air conveying the refuse would drop from 5,000 ft/min to about 1,800 ft/min as the air and refuse enter the furnace. Each transport pipe would enter the furnace windbox as the coal pipes do. The refuse burner itself would have no impellers but would be a hollow pipe. The refuse would be blown into the furnace flame zone and begin combustion with the pulverized coal.

V. Type and Specification of System Equipment

A. Forklifts

In the 2,000 ton storage scheme, two diesel powered forklift trucks would be provided to unload 75 yd^3 refuse trailers that had been transported by railroad car "piggyback". These forklifts have a load lift capacity of 90,000 pounds gross weight at 48 inch load center. The 75 yd^3 truck trailers will weigh about 62,000 pounds when containing 20 tons of refuse. It is estimated that each forklift truck could unload a minimum of 3 truck trailers per hour.

B. Tractor Trucks

In the 2,000 ton storage scheme, three diesel powered tractor trucks would be provided to transport the 75 yd^3 refuse trailers from the rail unloading area to the receiving building at which the trailers would be unloaded into underground receiving hoppers. It is estimated that each tractor truck could unload a minimum of 2 trucks per hour.

C. Gate House

The gate house is a small building provided for employees in the railroad unloading area. It would contain a small amount of plumbing, sewage, HVAC equipment, lights and plant telephone.

D. Blower Building

The blower building would be provided to house the positive displacement blowers which air blow refuse derived fuel from beneath the storage silos to the boiler furnaces.

The blower building would be of a sound-proofed design. Roof fans for ventilation, lighting, plant telephone, would be provided. An overhead traveling crane would be provided for blower maintenance. The Bull Run and Colbert blower buildings would contain 16 blowers and would be 85 feet long by 30 feet wide. The Cumberland and Kingston blower buildings would house 32 and 40 blowers, respectively. The Cumberland and Kingston blower buildings would be 180' x 30' and 176' x 30', respectively. A small control room would also be included in the blower building. This building will consist [illegible] bearing masonry on reinforced concrete footings. The roof structure will be structural steel with a monorail for the blower removal.

E. Receiving Building

The receiving building would house six receiving hoppers, six receiving hopper unloading screws, 3 belt conveyors, 3 rotary airlock feeders, and 3 blowers. The truck trailers are backed into the receiving building through any one of six 1/4 Hp motor operated overhead doors.

There would be an administrative and maintenance area located in the receiving building as well as a small kitchen, toilet, and locker room.

Dust collection hoods, ductwork, and ID fans would be provided at various locations on the ground floor and basement of the receiving buildings. A small bag filter and associated equipment would be provided for dust control.

Appropriate HVAC, sewage, lighting, plant telephones, plumbing facilities, service water, and service air lines would be provided for the receiving building. In addition, a fire protection system, sanitary drainage system including roof drainage and floor drainage systems, and duplex sump pump would be incorporated in the receiving building.

This would be a one story building with a basement. The basement is a reinforced concrete structure with outside reinforced concrete walls and a reinforced first floor slab containing the steel hoppers. The roof structure would be structural steel and steel deck. Its size would be 150' x 40' with an 18' deep basement for all four steam plant sites.

F. Receiving Hoppers

The compressed 75 yd^3 (16 to 20 ton) SWDF would be unloaded into receiving hoppers which would be suspended from the ground elevation floor. The SWDF would expand as it falls into one 20' x 15' x 10' (3,000 ft^3 = 112.5 yd^3) receiving hopper. The refuse would be about 20 lbs/ft^3 bulk density if 20 tons were loaded into the 75 yd^3 trailer. The refuse bulk density is expected to be about 10 lbs/ft^3 in the receiving hopper, thus the hopper will contain slightly less than 15 tons of refuse. The receiving hopper unloading screws have a rate of up to 50 tons/hr, so the extra 5 + ton that the hopper would not hold would be transported to the storage silo in about 6 to 7 minutes.

The receiving hoppers walls would be reinforced structural steel and would have a flat concrete bottom and vertical sidewalls.

There would be six receiving hoppers in the receiving building which would be loaded and unloaded independently of one another.

G. Receiving Hopper Screws

Each of the six receiving hoppers would contain one receiving hopper unloading screw. Each screw is a 20 ft long twin auger counter-rotation traversing screw that transfers the refuse derived fuel from the receiving hopper to a belt conveyor. Each screw is rated at an average unloading capacity of 40 ton/hr of SWDF with the capability of unloading 50 ton/hr as a maximum surge capability. The SWDF is assumed to have a bulk density of 4 lbs/ft^3, a nominal size of 3/4 inch, 25 percent moisture content, and of 92.6 percent combustible material while being unloaded. Each of the 6 hopper screws would be powered by a 100 Hp D.C. motor and would complete the 20 ft traverse of the 20' x 15' wide hopper by means of a 1/2 Hp motor. The speed of the unloading screw, and thus its unloading rate, would be controlled by the direct current motor and an AC/DC rectifier unit.

H. Belt Conveyors

Two receiving hopper screws would unload SWDF onto a common 72" wide, 30' long, belt conveyor that is located between two receiving building hoppers. Each of the three belt conveyors would be rated at an average unloading capacity of 80 ton/hr with the capability of unloading 100 ton/hr as a maximum surge capability. The SWDF is assumed to have a bulk density of 4 lbs/ft^3 and a nominal size of 3/4 inch while being unloaded by the horizontal (no incline) belt conveyor. The SWDF would be weighed by a standard mechanical beam belt scales with an accuracy of 0.5 percent. The belt conveyor would be powered by a 10 Hp motor while transferring the SWDF from the receiving hopper screws through fluffing rolls to the rotary air lock feeders.

The fluffing rolls are studded shafts which rotate at high speeds and break up any lumps or large pieces of intermatted SWDF. The 3 fluffing rolls are powered by three 2 Hp motors.

I. Air Lock Feeders at Receiving Building

Each of the three belt conveyors would unload into a rotary air lock feeder. Each of the three air lock feeders would have an 80 ton/hr capacity with surge capability to 100 ton/hr. The SWDF is assumed to have a bulk density of 4 lbs/ft^3 and a nominal size of 3/4 inch while being transferred via the air lock feeders from the belt conveyors into positive pressure transport pipes. Each air lock feeder would be powered by a 30 Hp motor.

The air lock feeder would have replaceable and adjustable inlet and outlet shear knives. The air lock rotor would have hard faced, helix, adjustable tips with replaceable liners of the air lock chrome finished .005" to .007" thick, provided with drive guard and TEFC motor, and inspection door. The discharge of the feeder would have a tee injector with a check valve, three access openings, and be mounted on a steel base.

J. Receiving Building Blowers and Pneumatic Equipment

Each air lock feeder would feed into a positive pressure 18" transport pipe through which a positive displacement air blower supplies a constant airflow of 11,000 ACFM to transport the SWDF into storage silos. Each of the three positive displacement blowers is rated to transport a maximum of 100 tons/hr of SWDF at 6,000 ft/min air velocity and a material loading $(\frac{\text{lb refuse}}{\text{lb air}}$ of 3.23. The SWDF is assumed to have a bulk density of 4 lb/ft^3 and a nominal particle size of 3/4".

The positive displacement blower is a constant volume machine which will automatically vary in horsepower consumption linearly with piping pressure loss resistance. The positive displacement blower will produce sufficient head to overcome air and material losses. In material conveying total energy losses are the sum of air losses and material energy losses. Air losses are made up of straight piping friction losses, elbow losses, pipe entrance losses, and pipe exiting losses. Material losses are made up of straight piping friction losses, elbow losses, lift losses, and material acceleration losses. A receiving building blower would also have a pressure drop resistance of 3-6" H_2O across a cyclone separator.

Inlet and outlet silencers would be provided on the blowers to reduce noise levels.

The motor horsepowers for the receiving building blowers for the Kingston, Cumberland, Bull Run, and Colbert plants are 350,350,300, and 300 Hp respectively. The Bull Run and Colbert horsepowers are less than the Kingston and Cumberland ones because of shorter length of transport piping.

These positive displacement blowers would be driven through a gear reducer and their constant volume CFM flows could be changed by changing gear ratios.

K. Receiving Building Transport Piping

The positive displacement blowers in the receiving building would provide up to a 3.8-4.0-psig maximum air pressure in the piping. The 3-18" transport pipes are carbon steel, flanged, standard schedule (3/8" wall thickness), and transport up to 100 tons/hr (each) of refuse derived fuel from the bottom of air lock feeders to 4-way diverting valves. The pipes exit the receiving building at grade level after beginning in the receiving building basement.

The elbows in this piping are 18" patented elbows with Ni-hard or R35 replaceable wear blacks. (Ref: drawing))A689-GB-52RO shows the elbow). The elbow is available in 15° circular segments; its replaceable wear back is available in 5°, 10°, and 20° circular segments.

L. Transfer Valve and House

Three 18", 4-way diverting valves are provided so that SWDF from each 18" transport pipe from the receiving building could be transferred to any one of the four storage silos. Each diverting valve would be automatically operated by 2-1/2 Hp motors, and controlled to prevent silo overfilling.

The transfer valve house would contain the three diverting valves. It would set on a concrete slab and have a roof vent fan. Its size would be 50' x 37' for all four steam plants.

M. Transport Piping to Top of Silo

There would be 12-18" carbon steel, standard schedule, flanged transport pipes connecting the three 4-way diverting valves with the four storage silos. These pipes empty into cyclone separators which are on top of the silos.

The elbows in this piping are 18" replaceable wear back elbows as described above.

N. Cyclone Separator

Each of the four cyclone separators would accept infeed from any combination or singular transport pipe flow. The cyclone separator separates air and refuse derived fuel and would be sized to handle 33,000 ACFM (ambient 90°F conditions) and up to 300 tons/hr of SWDF. Each cyclone would be equipped with a replaceable impact plate, a base impact liner, and body liners.

O. Rotating Discharge Nozzle

Each of the four rotating discharge nozzles would accept SWDF from the cyclone separator and would continuously rotate to divert the SWDF pile in the silo to the outside circumference and avoid a large center apex. Each rotating discharge nozzle would be powered by a 1/4-Hp motor.

P. Silo Air Cleaning

The transport air from the cyclone separator and the leakage through the boiler charging air lock feeder vents would be collected by 12" pipe ductwork and 2-30-Hp ID fans which draw the dust laden air through a bag filter house. The bag filters were assumed to be 12" diameter, 10' high bags with an air-to-cloth ratio of 3:1 (3 cfm/ft^2 cloth area) and a "can velocity" of 2 ft/sec. Two bag rappers would shake the dust from the bag filter cloth. Two air lock feeders and two screw conveyors would transfer the dust from the baghouse to the storage silo. The number of bag filters and the area of the baghouse was determined by using the following air to be cleaned: Cumberland - 46,000 ACFM, Bull Run - 38,000 ACFM, Colbert - 38,000 ACFM, and Kingston - 41,000 ACFM. These values were obtained by using the sum of all the receiving building blower air flow and 10 percent of the total boiler charging air flow.

Q. Silo

There would be four 500-ton storage silos to provide the desired 2,000-ton storage. Each silo would accept the SWDF infeed from its cyclone separator and rotating discharge nozzle and would unload via its sweep feed drive and outfeed conveyors. The silos will have a base diameter of 81', top deck diameter of 11.4', a height of 55.5', and a volume of 101, 230 ft^3. It is assumed that the SWDF will be a 10 lb/ft^3 bulk density in the storage silo. The bin sides would have a 3' horizontal/10'vertical slope. The slope decreases in diameter with increasing height designed to prevent SWDF from packing and bridging across the silo. There have been cases in which the sweep feed drive of the silo has had no SWDF to unload because of the bridging. The SWDF is more difficult to handle than most substances of the materials handling field because of its light weight, tendency to intermat, and large compressibility characteristics.

The silo shell would be carbon steel with rust proof coating, structural rings, and ribs. The bottom floor of the silo would be concrete and would set above the ground 15-17' to allow for feeders, weighing devices, etc., to be housed under the silo.

R. Silo Sweep Feed Drive

The silo sweep feed drive would unload the 10 lb/ft^3 refuse derived fuel by pushing the SWDF along the bottom of the silo floor into a recessed drag chain type outfeed conveyor. In this concept, reclaiming of SWDF from storage is accomplished by "chains" of "sweep buckets", each chain having one end pinned to a powered rotating pull ring (encircling the storage area) with the other end free or trailing. As the pull ring rotates around the periphery of the bin, the sweep chains automatically trail toward the center. The sweep buckets contact the stored SWDF at the outside of the pile and, as the pull ring continues to rotate, the buckets fill and the SWDF is swept through the floor openings onto a drag-chain type conveyor recessed in the floor of the bin.

The sweep feed pull ring would be powered by 2-20-,3-20, 3-20, and 3-25 Hp motors for the Kingston, Bull Run, Colbert, and Cumberland sites respectively. There would be one pull ring per silo with the number of "chains" of "sweep buckets" depending on the total amount (tons/hr) desired to reclaim from the storage silo. The sweep feed drive would be adjustable and speed controlled.

S. Silo Outfeed Conveyors

The drag chain type outfeed conveyors would transport the SWDF to a split flow discharge screw or a fluffing roll. The SWDF is assumed to have a 4 lb/ft^3 bulk density while being transported by the outfeed conveyors.

The number of outfeed conveyors per silo depends on the number of outfed streams per silo desired and the total amount desired to reclaim from the storage silo.

Until this point in the SWDF stream flow at the four steam plant sites, the receiving, conveying, and storing equipment have almost been identical. Only the receiving building blower horsepower, the air clean system, and the silo pull ring have been slightly different. The boiler charging equipment is the area in which the sizes and rates are different.

Each of the four storage silos shall have outfeed conveyors designed as follows: Bull Run, four at 8.12 tons/hr each; Colbert, four at 7.93 tons/hr each; Cumberland, eight at 12.22 tons/hr each; and the Kingston, five at 7.88 tons/hr each. Each conveyor motor horsepower for the Bull Run, Colbert, Cumberland, and Kingston plants will be 7.5, 7.5, 10, and 7.5 Hp respectively. The motors will be variable speed, DC motors which can control silo outfeed rates by controlling outfeed conveyor speed. An AC/DC rectifier system would also be provided.

T. Silo Split Flow Discharge Screw

The silo split flow discharge screw accepts SWDF from the outfeed conveyors at its center and divides that SWDF flow into two equal streams. The use of one split flow discharge screw at the discharge of one outfeed conveyor would replace the need for another outfeed conveyor, thus one larger capacity outfeed conveyor and one split flow discharge screw would replace two smaller capacity outfeed conveyors. This becomes significant when a fixed size storage silo with a fixed number of outfeed streams is desired and the silo does not have the capacity to contain the same number of outfeed conveyors as the desired outfeed streams.

Following the consultants example at Kingston, the cost estimates, motor lists, and flow diagrams included split flow discharge screws for all four plant sites. After these items were completed it was determined that the split flow discharge screws would be needed only in the Kingston arrangement. The Kingston plant would use 20-7.5 Hp, motor-driven split flow discharge screws rated at 7.88 tons/hr each. The Cumberland, Bull Run, and Colbert plants were to use sixteen screws at 24.4 tons/hr each, eight screws at 16.2 tons/hr each, and eight screws at 15.9 tons/hr each, respectively.

The split flow discharge screw is a variable pitch screw with half its length having a clockwise flighting and half having a counter-clockwise flighting.

U. Silo Air Lock Feeders and Metering Devices

The discharge of the split flow discharge screw for Kingston and outfeed drag chain conveyors for Cumberland, Bull Run, and Colbert would fall through ductwork, through fluffing rolls, and onto belt conveyor metering devices. The belt conveyor metering device would weigh outcoming SWDF and control SWDF silo unloading by automatically varying the speeds of the sweep feed drive system, outfeed conveyors, and split flow discharge screws to regulate each stream flow to a predetermined, set flow that would be blown into a boiler furnace. The belt conveyor weigh device would be a 30" wide belt, 10' pulley center conveyor driven by a 1-1/2 Hp motor for all four steam plant sites. The beam scale weight meter would have a 0.5% accuracy. The number and capacities of each metering belt conveyors are as follows: Bull Run, sixteen at 8.12 tons/hr; Colbert, sixteen at 7.93 tons/hr; Cumberland, thirty-two at 12.22 tons/hr; and Kingston, forty at 3.94 tons/hr. The SWDF is assumed to have a 4 lb/ft^3 bulk density on the belt.

The air lock feeders accept flow from the metering belt conveyors and inject it into a positive pressure transport pipe. The number and maximum capacities of each air lock feeders are as follows: Bull Run, sixteen at 8.12 tons/hr; Colbert, sixteen at 7.93 tons/hr; Cumberland, thirty-two at 12.22 tons/hr; and Kingston, forty at 3.94 tons/hr. The motor horsepower of each air lock feeder are as follows: Bull Run, 7.5 hp; Colbert, 7.5 hp; Cumberland 7.5 hp; and Kingston, 5 hp. The air lock feeders are designed for 8 inch, 10 inch, and 12 inch transport pipe for Kingston, Bull Run, Colbert, and Cumberland respectively.

The air lock feeders would have replaceable and adjustable inlet and outlet shear knives. The air lock rotor would have hard-faced, helix, adjustable tips. The replaceable liners of the air lock will have a chrome finish 0.005" to 0.007" thick. The air lock would be provided with drive guard and TEFC motor. The inlet chute, with an inspection door, would be provided to the feeder. The discharge of the feeder would have a tee injector with a check valve, and three access openings. The air locks and tee injector would be mounted on a steel base.

All fluffing rolls would be 2 hp with their number per plant site being the same as the metering belt conveyors and air lock feeders.

V. Blower Building Blowers

The blowers that blow metered (lb/hr) refuse-derived fuel from beneath the silos to the boiler furnaces are housed in a sound-proofed blower building. The blowers would be fitted with inlet silencers however.

In determining blower size capacities, material loadings of 0.92-1.19 $\left(\frac{\text{lb/refuse}}{\text{lb air}}\right)$ (with refuse supplying 20 percent of boiler heat input) and average air flow velocities of from 4945 to 5475 ft/min were determined.

As with the metering belt conveyors, fluffing rolls, and air lock feeders, the number of blowers per plant site would be as follows: Bull Run, 16; Colbert, 16; Cumberland, 32; and Kingston, 40. The positive displacement blowers would have the following maximum capacity characteristics: Bull Run - 3250 ACFM at 90°F, twelve 100-hp motors, four 75-hp motors; Colbert - 3050 ACFM at 90°F, sixteen 75-hp motors; Cumberland - 4850 ACFM at 90°F, thirty-two 125 hp motors; and Kingston - 2000 ACFM at 90°F, forty 40-hp motors. The blowers are sized for 10", 10", 12" and 8" transport pipes for Bull Run, Colbert, Cumberland, and Kingston, respectively. The blowers are capable of conveying 8.12 tons/hr, 7.93 tons/hr, 12.22 tons/hr, and 3.94 tons/hr for Bull Run, Colbert, Cumberland, and Kingston plants respectively.

These positive displacement blowers are belt driven and their cfm capacity can be varied by changing belt sheave sizes (limited by motor horsepower, of course).

W. Furnace Refuse Feed Transport Pipe

All of the transport piping to the boiler furnaces is of schedule 40 or 3/8" carbon steel material. The flanged transport piping is under a positive pressure of from 2.6 to 3.6 psig supplied by the positive displacement blowers. The following distances and sizes are for piping length and include elbow lengths (the actual amount of straight piping is slightly less and was accounted as such in the cost estimate): Bull Run - 10", 1098', average length, including 80' lift; Colbert - 10", 1158' average length, including 30' lift; Cumberland - 12", 977' average length, including 70' lift; Kingston - 8", 900' average length, including 50' lift.

The elbows from the blower house to the air lock feeders would be 8", 10", and 12" standard long radius elbows. The elbows from the air lock feeders to the boiler furnaces would be patented 8", 10", and 12" Ni-hard or R35 replaceable wear lock elbows. The elbows are available in 15° circular segments, their replaceable wear locks are available in 5°, 10°, and 20° circular segments.

The piping from the silos to the powerhouse would be above ground on pipe transport towers (see Kingston drawing 00N689-GB-IR0). Pipe rotation for erosion control would be provided by traveling cranes above the piping.

X. Controls

The receiving building hopper screws would normally operate at a constant speed and unloading rate. However, in order to handle surge rates and other nonstandard operating conditions that might occur, the unloading screws would be driven by a D.C. variable speed motor.

The material conveyed by the receiving building belt conveyors would be weighed by mechanical type beam scales and recorded on charts. These weighing devices would not control any equipment rates or speeds.

Each pneumatic conveying system transport pipe would be equipped with a pressure guage and two air pressure operated mercoid switches. One mercoid switch would be wired to the positive displacement blower; one mercoid switch would be wired to the various pieces of infeed conveying equipment. The mercoid switches would normally be closed and would be designed to open at a predetermined, set pressure. As mentioned previously, the total pressure drop across the pneumatic system (thus the discharge pressure that a positive displacement blower would automatically produce) is the sum of its air losses and material losses. When material is being fed into the pipe, the pressure rises. When the desired quantity (lb/hr) is being handled, the pressure in the line would be relatively constant and well within ratings of the blower and its motor. If, however, too large a quantity is fed into the line, or if the transport pipe begins plugging, the pressure produced by the blower would rise above the normal operating pressure. When a predetermined, set pressure is exceeded, the air operated mercoid pressure switch would open and send a current signal that would shut down all the infeed conveying equipment and stop the material flow. If the surge condition of plugging is corrected by stopping material flow, the blower discharge pressure would drop to the free-running pressure, the mercoid swith controlling the infeed system would close, the infeed conveying equipment and material infeed to the pneumatic system would restart automatically. If the plugged line did not clear, the blower discharge pressure would continue to rise to the point at which the mercoid switch wired to the blower would open and the blower would be shut down to prevent overheating or other damage. The plugging would have to be removed by using high pressure service air (less than the 150 psig rated pipe flanges) or by pipefitters disassembling the piping. The blower and infeed system for this one plugged pipe would require manual restarting after the obstruction was cleared. The other pneumatic system could continue to feed to the silo or boiler furnace while the plugging was cleared unless another pneumatic line was sharing a common infeed conveyor that had to be completely stopped to stop material infeed to the plugged transport pipe. The only example of this in the 2,000 ton storage study is the Kingston silo arrangement in which two pneumatic transport systems share one common drag chain type outfeed conveyor.

At the point where the air is brought into the control panel, a pulsation dampener is connected to provide a steady pressure to the pressure guage and mercoid switches.

The motors of all infeed conveying equipment that feeds material into the pneumatic system will be wired with interlock devices so that proper automatic sequence starting of the equipment would be accomplished.

The equipment should start in reverse order of the material flow. In the receiving building to silo pneumatic equipment, the motors would start in this sequence: bag house filter equipment, rotating discharge nozzle, blower, rotary airlock feeder, belt conveyor, fluffing roll, and hopper unloading screw. In the boiler charging system, the motors would start in this sequence: bag house filter equipment, blower, rotary airlock feeder, weighing belt conveyor, fluffing roll, split flow discharge screw, outfeed conveyors, and silo sweep feed drive. The shutdown of these two systems would be in reverse order as the startup. The reason for the start/stop sequences are to prevent material plugging because it was conveyed or left to settle somewhere in the material stream flow with nowhere to go; it accomplishes system material purging.

Time delay relays would also be used to allow a blower to come up to speed on startup or material to flow through the system before equipment was shut down. A time delay built into the mercoid switches would allow the high pressure to persist for a predetermined length of time before infeed equipment or blower was shut down.

The 4-way diverting valves between the receiving building and the silos would be automatically operated from silo high and low level control devices. Refuse would be fed into a silo until its high level alarm and control (or another silo's low level alarm and control) changed the material flow to another silo.

The boiler charging pneumatic equipment controls for interlocking and high pressure trips are the same as the receiving building pneumatic equipment and is discussed above.

The infeed rate of refuse to the boiler furnaces would be weighed and controlled by mechanical beam belt conveyor weigh devices capable of 0.5% accuracy. These weigh devices would be set at a predetermined level (lbs/hr) of outfeed by the control room operator. The weigh devices would control material outfeed from the silo by controlling the speed via D.C. motors of the outfeed conveyors and silo sweep feed drive. The fluffing rolls, rotary airlock feeders, split flow discharge screws and blowers would be sized for maximum desired material outflow and would not change in speed as material outflow varied.

A timer or a differential pressure cell would be used to clean the filter bay system.

Flow of the refuse to the burners is under control of the unit operator from the unit control room. He will control the silo sweep feeds, outfeed conveyors, split flow conveyors, metering devices, feeders, fluffing rolls and compressors, both for starting, stopping, and turndown of flow. The transport system is essentially an on-off process; the primary fuel provides the necessary control for load changes. The conversion of an existing system generator to burn refuse as a supplemental fuel generally does not require extensive control changes. Normally, the only added control is a "trip" which shuts off the feed of refuse in an emergency and a "permissive" that will not permit refuse firing until sufficient coal energy is available to ignite the refuse.

If load on the boiler drops below a fixed percent, or if the boiler trips, the refuse feeders are tripped and the blowers continue to operate until the conveying lines are empties. The blowers then shut down, thus avoiding line pluggage and potential maintenance problems.

On automatic readout of the flow from each feed from the weigh belt metering devices will be recorded in the boiler unit control room.

(Note: A list of all motors for each plant are listed in Table 9-1.)

TABLE 9 - 4 MOTOR LIST

		Kingston 5-9			Bull Run 1			Cumberland 1-2			Colbert 1-4		
Building	Equipment	No. I	NP	IN HP	No. I	NP	IN HP	No. I	NP	IN HP	No. I	NP	IN HP
Gatehouse	36,000 BTU A/C												
	Compressor	1	3	3									
	Blower	1	1/4	1/4									
	Toliet Fans	1	1/4	1/4									
Receiving	O.H. Door Operator	6	1/4	1-1/2	6	1/4	1-1/2	6	1/4	1-1/2	6	1/4	1-1/2
	BTLU A/C												
	Comp	1	5	5	1	5	5	1	5	5	1	5	5
	Blower	1	3/4	3/4	1	3/4	3/4	1	3/4	3/4	1	3/4	3/4
	Top Floor Dust Coll												
	Fans	1	10	10	1	10	10	1	10	10	1	10	10
	Rot Air Lock	1	1/4	1/4	1	1/4	1/4	1	1/4	1/4	1	1/4	1/4
	Basement Dust Coll												
	Fans	1	10	10	1	10	10	1	10	10	1	10	10
	Rot Air Lock	1	1/4	1/4	1	1/4	1/4	1	1/4	1/4	1	1/4	1/4
	Receiving Hopper												
	Unload Scrs	6	100	600	6	100	600	6	100	600	6	100	600
	Traverse	6	0.5	3	6	0.5	3	6	0.5	3	6	0.5	3
	Belt Conv	3	10	30	3	10	30	3	10	30	3	10	30
	Rot Air Lock	3	30	90	3	30	90	3	30	90	3	30	90
	Blowers	3	350	1050	3	350	1050	3	350	1050	3	350	1050
	Kitchen, Toilet, & Locker Fans	1	1	1	1	1	1	1	1	1	1	1	1
	Roff Exh Fans	6	5	30	6	5	30	6	5	30	6	5	30
	Bag Filter												
	Rapper	2	2	4	2	2	4	2	2	4	2	2	4
	Conveyor	2	1	1	2	1	2	2	1	2	2	1	2
	Sump Pump	2	15	30	2	15	30	2	15	30	2	15	30
Blower	Blowers	40	40	1600	12	100	1200	32	125	4000	16	75	1200
	Hoist												
	Lift	2	7-1/2	15	2	7-1/2	15	2	7-1/2	15	2	7-1/2	15
	Traverse	2	1-1/2	3	2	1-1/2	3	2	1-1/2	3	2	1-1/2	3
	Roof Supply Fans (Muffled)	6	5	30	6	1-1/2	9	6	5	30	6	1-1/2	9

2000 Ton Storage - 20% Refuse Firing

MOTOR LIST Sheet 1 NP - Nameplate - Hp each; No. I - Number installed; INHP - Installed horsepower

TABLE 9 - 4 (Cont'd) MOTOR LIST

		Kingston 5-9			Bull Run 1			Cumberland 1-2			Colbert 1-4		
Building	Equipment	No. I	NP	IN HP	No. I	NP	IN HP	No. I	NP	IN HP	No. I	NP	INHP
Silos	Drive	12	20	240	12	20	240	12	25	300	12	20	240
	Outfeed Conveyor	20	7.5	150	16	7.5	120	32	10	320	16	7.5	120
	Rotary Air Locks	40	5	200	16	7.5	120	32	7.5	240	16	7.5	120
	Rotating Disch Noz	4	1/4	1	4	1/4	1	4	1/4	1	4	1/4	1
	Metering Feeders	40	1-1/2	60	16	1-1/2	24	32	1-1/2	48	16	1/12	24
	Fluffing Rolls	40	2	80	16	2	32	32	2	64	16	2	32
	Split Flow Disch Screws	20	10	200	8	10	80	16	20	320	8	10	80
Air Clean	Fans	2	30	60	2	30	60	2	30	60	2	30	60
	Air Lock	2	2	4	2	2	4	2	2	4	2	2	4
	Conveyor	2	1	2	2	1	2	2	1	2	2	1	2
	Bag Rapper	2	2	4	2	2	4	2	2	4	2	2	4
Transfer Valve	4-Way Valve Motor	6	1/2	3	6	1/2	3	6	1/2	3	6	1/2	3
	Roof Vent	2	1	2	2	1	2	2	1	2	2	1	2
Miscellaneous	Pipe Handling Crane												
	Lift	1	7-1/2	7.5	2	7-1/2	15	2	7-1/2	15	1	7-1/2	7-1/2
	Traverse	1	1-1/2	1.5	2	1-1/2	3	2	1-1/2	3	1	1-1/2	1-1/2
	Travel	1	1	1	2	1	2	2	1	2	1	1	1

SECTION IX

REFERENCE DRAWINGS

DRAWING No.	TITLE
00A689-GB-7AR0	Resource Recovery System-Typical Refuse Burner Force Steam Generator
00A689-GB-7BR0	Resource Recovery Burner for CE Steam Generator
36-M-00N-689-GB-1R0	Power Plant Modifications Refuse Recovery System, 2000 Ton Storage
37-M-00N-689-GB-1R0	Power Plant Modifications Refuse Recovery System
37-M-00B-689-GB-2R0	Resource Recovery - Main Buildings
37-M-00W-689-GB-6R0	Resource Recovery System Refuse Burners - Plan and Elevations
46-M-00N-689-GB-1R0	Power Plant Modifications Refuse Recovery System
49-M-00N-689-1R0	Flow Diagram Refuse Recovery System - 1000 Ton Storage
49-M-00W-689-GB-8R0	Flow Diagram - Refuse Recovery System, 2000 Ton Storage

SECTION X

ECONOMIC ANALYSIS OF SOLID WASTE DERIVED FUEL USED AS A SUPPLEMENTAL FUEL IN A COAL-FIRED BOILER

This section of the report was prepared by TVA's Division of Power Resource Planning.

The concept of burning refuse in a power boiler has many facets, and we know that some of them have not been included in our economic analysis. For example, we have not tried to estimate the costs that would be required to increase the efficiency of the electrostatic precipitators in order to meet the particulate emission standards when burning refuse. This problem is discussed in other sections of the report.

The following items were recognized as major parts of our economic analysis:

1. The gross value of the solid waste derived fuel.
2. The costs for processed refuse receiving and storage facilities, pneumatic piping systems, and burner modifications.
3. The increased O&M expenses at the power plant when refuse is burned as a supplemental fuel.
4. The increased costs for ash disposal volume when solid waste derived fuel is burned at the power plant.
5. The costs for increased Btu input required relative to the amount of electricity generated due to boiler efficiency when solid waste-derived fuel is used as a supplemental fuel.
6. The change in total system production costs which can occur when a unit is committed to burn refuse. We have described this cost as an economic dispatch penalty.
7. The net value of the solid waste derived fuel.

Our evaluation of the gross value of the refuse was based upon a firing rate of 10 percent of the total Btu input to the boiler. Combustion Engineering, Inc., was the consultant for the design of refuse receiving and storage facilities, pneumatic transport, and burner modifications. They advised us that refuse firing was not recommended at unit loads below 50 percent of the maximum continuous rating of the unit. We have tried to recognize this restraint in estimating the amount of refuse we can burn in the power plants. We have assumed that the SWDF would be used to replace coal that is in inventory at the plants, and our coal cost data were based upon the estimated costs for future delivered prices for the plants (1979 estimated coal prices). The estimated values were based upon dollars per ton of municipal solid waste collected (Table 10-1).

The capital expenditures required at the power plants for refuse receiving and storage facilities, refuse handling, transport piping, and boiler modifications were estimated by the Office of Engineering Design and Construction. The estimated costs ranged from $25.5 million for a plant with one 950-MW unit to $36 million for a plant with two 1,300-MW units. When expressed as dollars/kW, these costs ranged from $14/kW for the 2,600-MW plant to $34/kW for a 4-unit plant with a total capacity of 846.5 MW. The costs were also expressed in terms of the investment required per ton of refuse to be burned in one day, and they ranged from $17,000 per ton each day for one 950-MW unit to $20,000 per ton each day for a 1,000-MW plant with five units (Table 10-2).

TABLE 10-1

GROSS VALUE OF PROCESSED REFUSE AS SUPPLEMENTAL FUEL

Plant	Tons/Day	Dollars/Ton of Municipal Solid Waste
Bull Run 1	1,500	3.8*
Colbert 1-4	1,000	5.9
Cumberland 1-2	2,000	4.0
Kingston 5-9	1,000	5.5

*Only 75 percent of the processed refuse could be burned at Bull Run due to only one unit at the plant.

TABLE 10-2

CAPITAL COSTS FOR RECEIVING AND STORING REFUSE AND BOILER MODIFICATIONS

Plant	Nameplate Capacity	Millions of Dollars	Dollars per Tons of MSW	Dollars per kW of Capacity
Bull Run 1	950 MW	25.5	5.3	27
Colbert 1-4	846.5 MW	29.0	9.2	34
Cumberland 1-2	2,600 MW	36.0	5.7	14
Kingston 5-9	1,000 MW	30.0	9.5	30

The estimate for the increased O&M expenses due to the use of processed refuse as supplemental fuel was based upon the use of historical records and current costs for coal-handling expenses at the plant. These costs were escalated using escalation rates prepared by the TVA escalation committee. By the use of cash flow discounts, the costs were expressed in 1977 dollars to obtain the data as shown in Table 10-3.

TABLE 10-3

COSTS FOR INCREASED OPERATING AND MAINTENANCE EXPENSES DUE TO BURNING REFUSE

Plant	Nameplate Capacity	Tons/Day	Dollars/Ton
Bull Run 1	950 MW	1,500	0.3
Colbert 1-4	846.5 MW	1,000	0.4
Cumberland 1-2	2,600 MW	2,000	0.3
Kingston 5-9	1,000 MW	1,000	0.7

When solid waste derived fuel is burned as a supplementary fuel in a coal-fired boiler the bottom ash will be greater in volume than the bottom ash when coal is used as fuel. This is true because the Btu content of the processed refuse is usually about one-half the Btu content of coal, and the ash content is about the same, or greater, than the ash content of coal. The costs for ash disposal volume at our coal-fired plants have been increasing in recent years. The Division of Power Production prepared the cost estimate for our use in estimating the costs for increased ash disposal volume at the plants when the units were committed to burn refuse. A summary of these costs is shown in Table 10-4.

TABLE 10-4

ESTIMATED COSTS FOR INCREASED ASH DISPOSAL VOLUME REQUIRED FOR SOLID WASTE DERIVED FUEL

Plant	Tons/Day	Dollars/Ton
Bull Run 1	1,500	0.2
Colbert 1-4	1,000	0.3
Cumberland 1-2	2,000	0.0
Kingston 5-9	1,000	0.2

The use of solid waste derived fuel as supplementary fuel will cause a change in boiler efficiency due to the moisture in the fuel and the excess air used for pneumatic transport and for injecting the refuse into the furnace. The consultant for burner modifications and other plant requirements, Combustion Engineering, Inc., advised us that the boiler efficiency would decrease 2.06 percent when firing refuse at 20 percent of the total Btu input required for the maximum continuous rating of the unit. Also, we were told this was a linear relationship when refuse firing was at levels of less than 20 percent of the total Btu input. We estimated the boiler efficiency change would be one percent when the refuse firing was limited to 10 percent of the gross Btu input to the furnace. Also, we made the assumption that the change in boiler efficiency would be overcome by the increased firing of coal. The costs for the increased amount of coal consumed was expressed in dollars per ton of municipal solid waste. These costs are given in Table 10-5 below.

TABLE 10-5

ESTIMATED COSTS FOR THE CHANGE IN BOILER EFFICIENCY DUE TO USE OF PROCESSED REFUSE AS SUPPLEMENTAL FUEL

Plant	Tons/Day	Dollars/Ton
Bull Run 1	1,500	0.4
Colbert 1-4	1,000	0.6
Cumberland 1-2	2,000	0.2*
Kingston 5-9	1,000	0.8

*Refuse firing at Cumberland was 4 percent of the total Btu input.

TVA uses economic dispatch programs to achieve optimum allocation of loads to the generating plants. The optimum economic condition is reached when each generating unit is scheduled to operate at its lowest incremental cost. When a commitment is made to burn processed refuse as a supplemental fuel, the units may be required to remain in operation while other units on our system with lower incremental cost will be reduced in output or taken out of service. This type of operation will result in an increase in total system operating costs. We have described this increase in operating costs as an economic dispatch penalty. We estimated the value of economic dispatch penalty by using computer programs to simulate the operation of the TVA power system and assigning the generation required to the plants with the lowest incremental costs. Basic studies were made with no plants committed to burn refuse. Then additional studies were made with each plant in turn committed to burn refuse. The costs for the economic dispatch penalty for 20 years of refuse burning were expressed in terms of dollars per ton of solid waste. These costs were shown in Table 10-6.

TABLE 10-6

ESTIMATED COSTS FOR ECONOMIC DISPATCH PENALTY WHEN PROCESSED REFUSE IS USED AS SUPPLEMENTAL FUEL

Plant	Tons/Day	Dollars/Ton
Bull Run 1	1,500	0.4
Colbert 1-4	1,000	2.7
Cumberland 1-2	2,000	-
Kingston 5-9	1,000	-

The net value per ton of processed refuse was developed for each plant used in our economic studies. These values are shown in Table 10-7. These net values ranged from -13.6 dollars to -4.1 dollars. We expressed the net values in terms of municipal solid waste, and these values are shown in Table 10-8. The costs ranged from -7.3 dollars to -2.2 dollars. These results indicate that the use of processed refuse as supplemental fuel at the four plants could result in costs in excess of the fuel value of over $5.7 million in one year of operation. Our main concern is that the use of power boilers for refuse burning should not result in these costs being added to the costs of producing electrical energy at the plants.

The Bull Run Steam Plant was selected for additional studies concerning the use of processed refuse as supplemental fuel. The Office of Engineering Design and Construction prepared two additional cost estimates for the plant. A refuse receiving and storage facility to handle 1,500 tons per day with storage silos for 1,000 tons of refuse was estimated to cost $17 million. This reduction in capital expenditures lowered the capital cost per ton of municipal solid waste from $5.30 to $3.60 per ton. A system to receive 1,500 tons of processed refuse each day with minimum storage requirements was estimated to cost $14 million. This lower capital expenditure could result in a capital cost of 2.90 per ton of municipal solid waste. In summary, these reduced capital expenditures could result in net changes of $1.70 and $2.40, respectively, in comparison with the value of $-2.80 for Bull Run as shown on Table 10-8.

Table 10-7

SYSTEMS EVALUATION OF PROCESSED REFUSE AS SUPPLEMENTAL FUEL IN POWER BOILERS[1]

Dollars Per Ton of Processed Refuse

	Bull Run 1,500 Tons/Day $/Ton	Colbert 1-4 1,000 Tons/Day $/Ton	Cumberland 1-2 2,000 Tons/Day $/Ton	Kingston 5-9 1,000 Tons/Day $/Ton	Total System 5,500 Tons/Day $/Ton
Gross Value of Refuse as Supplemental Fuel	7.6	10.8	7.6	10.2	8.6
Capital Costs for Receiving and Storing Refuse and Boiler Modifications	10.0	17.0	10.6	17.6	12.8
Costs for Increased O&M Expense Because of Refuse Burning	0.5	0.8	0.6	1.3	0.7
Costs for Increased Ash Disposal Volume	0.4	0.5	0.1	0.4	0.3
Costs for Change in Boiler Efficiency Because of Refuse Burning	0.8	1.1	0.4	1.5	0.9
Costs for Economic Dispatch Penalty	0.8	5.0	-	-	1.13
Net Value of Refuse as Fuel	-4.9	-13.6	-4.1	-10.6	-7.2

1/ Data is based upon 1980-89 as the 10-year project life. Interest rate 8-1/2%. Refuse deliveries 5 days per week.

Table 10-8

SYSTEMS EVALUATION OF PROCESSED REFUSE AS SUPPLEMENTAL FUEL IN POWER BOILERS[1]

Dollars Per Ton of Solid Waste Collected

	Bull Run 1,500 Tons/Day $/Ton	Colbert 1-4 1,000 Tons/Day $/Ton	Cumberland 1-2 2,000 Tons/Day $/Ton	Kingston 5-9 1,000 Tons/Day $/Ton	Total System 5,500 Tons/Day $/Ton
Gross Value of Refuse as Supplemental Fuel	3.8	5.9	4.0	5.5	4.7
Capital Costs for Receiving and Storing Refuse and Boiler Modifications	5.3	9.2	5.7	9.5	7.0
*Costs for Increased O&M Expense Because of Refuse Burning	0.3	0.4	0.3	0.7	0.4
Costs for Increased Ash Disposal Volume	0.2	0.3	-	0.2	0.2
Costs for Change in Boiler Efficiency Because of Refuse Burning	0.4	0.6	0.2	0.8	0.5
Costs for Economic Dispatch Penalty	0.4	2.7	-	-	0.6
Net Value of Refuse as Fuel	-2.8	-7.3	-2.2	-5.7	-4.0

*Estimated land fill cost of $0.10 per ton of incoming MSW is not included.

[1] Data is based upon 1980-89 as the 10-year project life. Interest rate 8-1/2%. Refuse deliveries 5 days per week.

SECTION XI

TECHNICAL PROBLEMS ASSOCIATED WITH BURNING SOLID WASTE DERIVED FUEL IN A COAL-FIRED BOILER

This section of the report was prepared by TVA's Division of Power Production.

Based on literature searches and consulting with Union Electric Company, St. Louis, Missouri, it may be premature to commit more than two TVA boilers to supplemental refuse firing until certain technical problems can be fully evaluated. There is considerable experience in refuse firing in stokers and incinerators, but to date Union Electric is the only organization in the United States firing refuse in suspension with pulverized coal. Union Electric's work is encouraging; however, they warn that extrapolation of their results to other units is dangerous because of differences in boiler design, coal, and refuse. We feel that potential technical and operating problems (especially corrosion, precipitator performance, and bottom ash fallout) must be characterized at a TVA plant to assure that plant availability and consumer power rates will not be adversely affected.

Effect on Operation

Operators and shift superintendents at Union Electric's Meramec Station report that refuse firing has had no discernible effects on furnace or convection passes. Frequent or sudden interruptions of the refuse feed have not required any change in operating techniques. The boiler combustion controls easily accommodate variations in refuse quantity and quality by varying the amount of coal fired. It is reasonable to assume that TVA would obtain similar results in the operation of the boilers with a heat input ratio of 10 percent refuse to 90 percent coal.

There has been no indication to date from Union Electric's experience that solid waste fuel has any greater tendency to form slag than does Illinois bituminous coal. The ash fusion temperatures of solid waste apparently are about the same as those of Illinois bituminous coal. Utility personnel have voiced the opinion that the furnace appears to be cleaner when solid waste is fired in combination with coal than when coal is fired alone. Although the reason for this is not clear, it is assumed that paper forms a nonslagging dry ash.

Combustion Engineering estimates that boiler efficiency on a Kingston unit (5-9) would drop 1.10 and 2.06 percentage points from full load design efficiency of 88.69 percent when firing 10 percent and 20 percent refuse, respectively, on a heat input basis. This loss is attributed to increased fuel moisture and dry gas losses. The dry gas loss increases because of the increase in total air required to burn the refuse-coal mix compared to an equivalent amount of coal. We anticipate similar penalties on other units.

Handling and disposal of bottom ash is a major concern with supplemental firing of refuse with pulverized coal. Increased bottom ash accumulation rate may require modification of disposal systems at plants where existing systems are marginal. Experience and tests at Meramec indicate that bottom ash accumulation rate may increase by as much as 2 to 5 times with refuse compared to coal only. Changes in physical properties and constituents of bottom ash may affect quality of sluice water discharged to navigable waterways, thus jeopardizing National Pollutant Discharge Elimination System (NPDES) permits and/or requiring treatment to comply with the Federal Water Pollution Control Act. Fallout of some large particles of unburned organic matter into the ash pit is unavoidable. This was a severe problem at Meramec and addition of an air classifier to the processing plant has helped. If organic fallout is ufficiently great the regulatory agencies may require that bottom ash be landfilled. Combustion Engineering predicts that organic fallout will be insignificant; however, this can only be finally determined by testing.

The majority of TVA coal-fired units are not continuously base loaded and will increasingly be subjected to load savings as more efficient nuclear units become available. Union Electric has reported problems maintaining steam temperature when firing refuse at less than 75 percent rated load at Meramec. Additionally, Combustion Engineering recommends against firing refuse at less than 50 percent rated load. Operation of old coal-fired units at greater than 75 percent or even 50 percent rated load instead of more efficient units will have a definite negative economic impact on the program. This impact can be reduced by firing refuse at reduced load. Tests are needed to completely characterize supplemental refuse firing in suspension with coal. That is, optimize refuse firing rate over the entire range in terms of mill configuration, fallout of organics, and steam and gas temperatures.

Carryover of oversized particles which might start serious pluggage in Ljungstrom regenerative air heaters is a potential problem with supplemental refuse firing. Union Electric, however, has reported no problems with their tubular air heaters at Meramec Station. Tests are needed to determine optimum burner elevation. Burners located too low in the furnace may result in excessive fallout of oversized particles while burners located too high may promote carryover to the air heaters.

Burning refuse could sufficiently alter the characteristics of fly ash to effect its marketability. Although Union Electric did not encounter this problem, the potential exists. Should the market for fly ash be lost, the economic impact would have to be absorbed by the program.

Corrosion

Based on information from literature and Union Electric, the possibility of catastrophic corrosion with supplemental refuse firing is not considered great; however, both emphasize that there is a lack of conclusive data and further testing is needed. For example, Union Electric has been involved in a corrosion test program since April 1972 and although their experience supports the "no appreciable harm" hypothesis, they still believe the results are inconclusive (see attachment). We, therefore, recommend a one-year test program be implemented on a TVA boiler before committing to the full scale regional refuse disposal program. This program would include comparative tube wall thickness measurements, installation of test sections of new tubing, and corrosion probing.

Fireside corrosion in coal-fired steam generators has historically been associated with sulfur as complex sulfates, SO_3, and sulfuric acid. Since refuse contains considerably less sulfur than coal, there is no obvious reason why supplemental firing should adversely effect this situation.

Of major concern in regard to corrosion is the presence of chlorine or chlorides from vinyl plastics as well as some heavy metal oxides not normally observed in coal ash. Evidence from both laboratory and field studies indicates a strong correlation between severity of high temperature deposits and corrosion and coal composition. Coals that are high in alkalis, sulfur, and chlorine cause the most difficulties. Results of work in Great Britain suggest that chloride contents of alkali sulfate deposits are important in accelerating corrosion rates. Chlorine content of U.S. coals range from 0 to 0.6 percent. Chlorine content of solid waste derived fuel from Meramec Station reported by EPA (reference 6) ranged from 0.15 to 0.95 percent classifying it a moderate to high chlorine fuel compared to coal.

Erosion

Because of increased gas velocities and particulate loading, metal wastage by erosion is a potential problem. Since only a small percentage of the fuel is to be refuse, the extent of erosion is expected to be negligible. Union Electric's experience supports this expectation. However, the full extent of erosion in a particular boiler can only be determined by actual firing of refuse with coal.

Burner Design

Currently Union Electric fires refuse at Meramec Station through straight pipes located in ports once occupied by gas nozzles. They have a refuse burner study program underway, but results are not yet available. Studies are needed to obtain optimum burner design and location for maximum combustion efficiency by assuring sufficient air-fuel mixing and retention at combustion temperature. Location (elevation) of burners is an important consideration in assuring retention at combustion temperature. At reduced load, burners located too low may result in excessive fallout of oversized particles and unburned organics into the ash pit. At higher loads, carryover of unburned particles and air heater plugging may be a problem if burners are too high.

Electrostatic Precipitator Performance

There is concern that supplemental firing of refuse with pulverized coal may adversely effect ESP performance for the following reasons:

1. Design migration velocities and inlet grain loadings may be exceeded because of additional air required for combustion and higher moisture and ash content of refuse compared to that of an equivalent amount of coal.

2. Surface resistivity of ash may increase if lower sulfur content of refuse effectively lowers flue gas SO_3 content.

The effect of supplemental refuse firing on electrostatic precipitator performance has not yet been characterized. Early independent tests by Union Electric and Midwest Research Institute (sponsored by EPA) produced conflicting results and were criticized for not optimizing ESP electrical parameters and insufficient stabilization time when switching fuels. This led to additional testing by EPA/MRI. Preliminary results of these tests conducted in March and May 1975 are available; however, they are also inconclusive. Efficiencies at reduced load fell within the range of previous tests (UE & EPA/MRI) but three of four runs at full load with refuse indicated losses of 2 to 10 percentage points. MRI suspects an undetected ESP upset and/or sampling equipment malfunction. Additional tests are planned.

During the latest set of EPA/MRI tests Southern Research Institute conducted particle size distribution tests. MRI reported that when firing refuse, ESP inlet size distribution (with cascade impactors) did not show any significant variation with unit load or percent refuse. Neither did it show any marked change from coal-only tests.

Additionally, SRI measured insitu ash resistivities during the latest EPA/MRI tests. Resistivities during the full load (140 MW) coal plus refuse tests ranged from 4.2×10^{10} to 2.1×10^{11} ohm-cm while they ranged from 1.4×10^{10} to 5.8×10^{10} ohm-cm during the 140-MW coal only tests. Precipitators are normally designed to handle ash ranging in resistivity from 10^7 to 10^{10} ohm-cm. Resistivities on the order of 10^{11} ohm-cm are considered a grey area where collection problems may be expected to occur. We agree with MRI that the difference in resistivity is not great enough to explain the difference in full load collection efficiency noted in their test. Additionally, we feel that the difference in resistivity cannot be conclusively attributed to refuse burning because of the time lapse (one month) between coal only, and coal plus refuse tests. Changes in coal alone might account for variations of this magnitude.

Federal particulate emission standards will most likely not be changed for existing coal-fired steam generators firing small percentages of refuse. The preliminary recommendation of EPA's technical group (reference 7) is that Standards of Performance for New Stationary Sources, Fossil Fuel Fired Steam Generator Category be modified to include coal-fired units burning municipal refuse. That is, new units supplementing coal with municipal solid waste derived fuel will most likely have to meet the 0.1 lb/10^6 Btu limit unless the state standard is more stringent. Existing units modified to supplement coal with municipal refuse will have to meet existing state standards unless the states modify them.

We conclude that should refuse be used as a supplemental fuel at any TVA plant, extensive ESP testing will be necessary to assure compliance with particulate emission standards. Precipitators at Paradise, Gallatin, Watts Bar, Widows Creek 7 and 8, Shawnee, Cumberland, and Colbert 1-4 are marginal and can stand no performance degradation. Upgrading of precipitators is underway at Johnsonville 1-6, Kingston, Widows Creek 1-6, Colbert 5, and is planned at Bull Run. Currently no performance degradation can be tolerated at these plants. Some slight degradation (in the order of 1.0 percentage point) may be acceptable at Allen, John Sevier, and Johnsonville 7-10.

Gaseous Emissions (NO_x, SO_2)

It is not expected that supplementing pulverized coal with small percentages of refuse will have a significant effect on NO_x and SO_2 emissions. The high moisture content of refuse may reduce combustion zone temperature enough to reduce NO_x slightly. SO_2 might also be slightly reduced because of the low-sulfur content of refuse. Gaseous emission tests by EPA/MRI at Meramec, however, detected no significant differences in NO_x and SO_2 when firing refuse with pulverized coal.

If TVA elects to supplement coal with SWDF, NO_x and SO_2 emissions should be characterized by actual testing.

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ATTACHMENT
(SECTION XI)

BOILER CORROSION & EROSION STUDY - ST. LOUIS/UNION ELECTRIC DEMONSTRATION PROJECT

In order to evaluate any possible deleterious effects on boiler tubing resulting from combination coal and refuse burning, a comprehensive testing program has been developed and is being actively pursued at present.

Prior to startup of the refuse burning installation on units 1 & 2 at Meramec Plant, the following sections of new tubing were installed in the generators:

	Unit - 1	Unit - 2
Date Installed	December 1971	February 1972
Waterwall	SA 210	SA 210
Reheater	SA 213 T22	SA 213 T22
Secondary Superheater	SA 213 T5C	SA 213 T5C

During a scheduled maintenance outage of unit 1 in September 1974, these samples were removed for evaluation. During the period December 1971 through September 1974, exposure of the specimens to coal and refuse combustion was as follows:

Hours Unit on Load	19,116
Tons of Coal Burned	753,422
Tons of Refuse Burned	5,102
Hours Refuse Burned	1,594

Portions of the unit 1 samples were metallographically examined at Union Electric's laboratory and were also sent to Monsanto Company, St. Louis for electron microprobe examination. Results indicated no boiler tube degradation other than would normally be associated with 100 percent coal burning operations. Essentially no lead, zinc, or chloride compounds were found in the tube scale.

Subsequent to the above analytical work, during a scheduled maintenance outage of unit 2 in March 1975, the specimens installed in February 1972 were removed. During the period covered, this unit burned approximately 33,000 tons of refuse, representing a substantial increase of exposure compared to unit 1.

Portions of these specimens were sent to Battelle Memorial Institute, Columbus, Ohio for complete investigation of deposits, scale, and tube wastage mechanisms. This work has been completed. Microscopic X-ray diffraction and X-ray emission tests and other procedures which were performed indicated that scale, deposits and metal wastage was only that which would be expected from coal combustion environments.

In addition to the above test results, no physical evidence or boiler tube failures can be attributed to the firing of solid waste in combination with pulverized coal in Meramec units 1 & 2.

Further corrosion investigations have also been in progress through use of two high temperature probes, one waterwall corrosion probe and one "cold end" probe (installed in the gas stream entering the electrostatic precipitator), purchased from Combustion Engineering Corporation and installed in Meramec unit 2. The high temperature probes were made of 347SS, 321SS, T9, and T22 alloys. The waterwall probe was made of carbon steel (SA192). Exposure of the probes was as follows:

Probe	Refuse Tons	Coal Tons	Boiler Hours	Refuse Hours
HT #1	2983	51545	1408	294
HT #2	7280	107587	2249	706
Waterwall	19524	375995	8999	2091

The high temperature probes were removed because of various mechanical defects in the probes themselves (not corrosion related) and due to boiler operational considerations. All four probes have been sent to Combustion Engineering's Kreisinger Development Laboratory at Windsor, Connecticut for evaluation. No data on these samples is available at this time.

A new high temperature probe containing welds in 347SS, 304SS, T9 with a 347 weld and T11 and T22 materials has been fabricated by Combustion Engineering and installed in Meramec unit 2. The primary purpose of this probe is to determine if stress corrosion cracking is a factor in refuse burning operations.

The above summary must be considered as only partial and therefore inconclusive as regards corrosion effects of refuse and coal burning, and merely constitutes an update on our efforts. Full definitive information will be released when all testing and evaluation is completed.

Paul R. Brendel
Assistant Manager
Solid Waste Utilization
System
July 23, 1975

SECTION XII

WASTE GASIFICATION AS AN ALTERNATIVE TO SOLID FUEL PROCESSING

The Institute for Energy Analysis (IEA), a division of the Oak Ridge Associated Universities, was retained under contract TV-42180A to assess the viability of a gasification alternative to solid fuel. In that assessment, the organic fraction of solid waste was viewed as material to be gasified, with the resulting gaseous product usable as a fuel or as a chemical feedstock for further processing. The basic system, or solid fuel concept, views the organic material in the region's wastes as a combustible solid fuel to be burned in steam plants modified for that purpose. In addition, the basic system would provide for recovery and recycling of the mixed metals and glass in the inorganic fraction. As was the case with the basic system, gasification alternatives are compatible with the recovery of metals and glass from the inorganic waste fraction.

The material in this section is taken from the IEA report, "Gasification of Solid Waste - An Alternative to Solid Fuel."

The IEA study consisted of the following areas of investigation:

1. Assessment of candidate gasification systems.
2. Selection and pricing of gasification systems of different capacities to allow for determining any economies of scale.
3. Identification of secondary systems which could use the product of the selected gasification system, to include as a minimum methanol and ammonia synthesis.
4. Evaluation of the costs of collection, transportation, processing, storage of end products and any necessary modifications to existing facilities.
5. Determination of any environmental issues associated with the production and use of alternative end products.
6. Projection of supply and demand for the end products.
7. Evaluation of overall system costs.

Selection Criteria

The following criteria were used as guides in the selection and assessment of alternatives:

1. The implementation of an alternative should alleviate the region's waste disposal problems without increasing solid waste disposal costs.
2. The manufacture and use of an alternative's products should not have any greater adverse environmental impact than the impact associated with manufacturing and using the products it competes with or replaces.
3. The alternative's products should replace or supplement items in short supply.
4. It is desirable that an alternative's products be usable by TVA, and therefore not require any external sales or marketing activity.
5. The funding and operation of any alternative system by TVA should be compatible with, or be a logical extension of, TVA's charter.
6. The price of any alternative's products should be competitive.

Candidate Alternatives

In view of these criteria, the following candidates were considered:

- Production of a gaseous fuel for base-loaded coal-fired power plants.

- Production of a gaseous fuel for peaking gas turbines.

- Production of a synthetic natural gas for pipeline distribution.

- Production of a gaseous feedstock for methanol synthesis.

- Production of a gaseous feedstock for ammonia synthesis.

a. Production of a Gaseous Fuel for Base-Loaded Coal-Fired Power Plants

The TVA power system uses a solid fuel--coal--to generate much of its power. The basic resource recovery system would produce a solid fuel which would supplement a portion of this coal. Using gas as a supplemental fuel in TVA's base-loaded plant does not appear advisable for several reasons.

First, if any coal supply is to be supplemented it can be done with the solid waste derived solid fuel, without incurring the additional expense associated with gasification. Second, assuming that a synthetic gas intended for use in base power boilers would have a relatively low Btu content as compared with natural gas, the expense of distribution and storage could be considerable unless the gas were produced adjacent to the intended user.

The use of a gaseous fuel in base-loaded power plants would meet most of the selection criteria. However, such a fuel would fall short of competing with the fuel it would partially replace - coal.

Coal prices would have to climb to $70 per ton to begin to make gas an economic competitor, without considering any additional modification or increased operating maintenance (O&M) costs associated with its use. Although rejected as a viable alternative, the cost of producing power from gaseous fuel in a boiler was estimated. This estimate is given in the IEA report.

b. Production of a Gaseous Fuel for Peaking Gas Turbines

While coal can still be purchased for around 85¢ per 10^6 Btu, the latest price paid by TVA for gas turbine fuel --No. 2 distillate oil--is approximately $2.83 per 10^6 Btu [based on the oil's Lower Heating Value (LHV)]. Coal, as is the case with other solids, is not usable in gas turbines. Gas is one of many fuels that can be burned in such devices. Gaseous fuel, especially the more expensive synthetic versions, appear to be more viable alternatives for generating peaking power than for base-load power as such fuels would be competing with higher priced liquids. This is especially true when one considers that the feedstock for the gasification process, solid waste, is quite similar to solid waste derived fuel, the product which is itself a potential substitute for coal in base power application.

However, unless the gaseous fuel is produced at the using location, a gas turbine installation, distribution of that gas could present difficult problems. The heating value of the syngas would approximate 310 Btu per scf, a characteristic that would prohibit mixing it in a pipeline with natural gas with a heating value of 1,000 Btu per scf. Potential using locations --Allen, Colbert, Gallatin, and Johnsonville--are all quite remote from the centers of waste generation analyzed in this study. Therefore, distribution of a low-Btu syngas would necessitate either a separate pipeline, methanation to a higher Btu value and insertion into an existing pipeline, or liquefaction at the processing plant and transportation under cryogenic conditions with regasification at the gas turbine site.

Because of the intermittent demand associated with peaking power, extremely large quantities of fuel would have to be kept in storage to assure availability when needed. Gallatin's anticipated demand alone would require storing as much as 3.55×10^9 SCF at 310-Btu syngas. TVA presently has 15×10^6 gallons of storage capacity at Gallatin for their present peaking fuel--No. 2 distillate oil. However, there are no provisions for storing gas at Gallatin, or at any other gas turbine installations. Storage of as much energy in 310-Btu syngas as is contained in 15×10^6 gallons of No. 2 oil would take approximately 1,050 times the No. 2 oil storage volume, even if the gas were maintained at three atmospheres.

If, to eliminate the need for excessive storage, the gasification plant were sized to keep pace with peak demand with syngas, the plant would be excessively large and inefficient, running at far less than 50 percent capacity most of the year. Furthermore, such a plant would require base stockpiles of solid waste, a decaying mass that must be sheltered from the elements, to assure adequate feedstocks for full capacity operation.

For the foregoing reasons, production of a gaseous fuel as a peaking fuel, does not appear to be a viable alternative. As was the case for base-loaded application of a gaseous fuel, the IEA report contains some rough cost estimates for such a use.

c. Production of a Synthetic Natural Gas for Pipeline Distribution

To produce a synthetic gas which would be compatible with the natural gas distributed through the region's numerous pipelines, the MSW must first be gasified and then put through the methanation step. This would produce a high-quality synthetic natural gas (SNG) of approximately 924 Btu per SCF.

It would not be difficult to locate a processing plant near an existing natural gas pipeline. It should also not be too difficult to arrange an agreement with the carrier to insert the SNG into the latter's distribution system, in return for a price near the existing market level. However, methanation is an expensive step. Natural gas prices are still relatively low. The degree to which they will increase is dependent on several variables, one of the most significatn of which is the removal of price control measures.

For refuse-derived methane to be competitive with natural gas, the market price for that product will have to rise to \$4.65 per 10^6 Btu, a price which does not appear to be on the horizon. The IEA report presents some of the cost elements which contribute to such high methane production costs. The use of SNG as a fuel for base-loaded power plants or gas turbines was rejected as a viable alternative for the dual reasons of cost and storage requirements.

d. Production of a Gaseous Feedstock for Methanol Synthesis

TVA has been using gas turbines to help meet peak power demand since 1972. In June 1975, the system-wide gas turbine capacity was increased to 2512.4 MW, giving TVA approximately 6 percent of the total U.S. installed gas turbine capacity. These turbines burn No. 2 distillate oil. With the exception of a 5-month period in 1973, when natural gas was used to supplement the No. 2 oil at Allen, No. 2 distillate oil has been the only fuel used in the turbines.

In the 1972-1975 period, prices paid by TVA for No. 2 oil have tripled, with continued price increases projected. Although modification to existing gas turbines would be necessary to allow burning of a different liquid, such as fuel-grade methanol (MeOH), the changes are neither overly dramatic or excessively expensive. The Turbo Power and Marine Systems Corporation reports the successful burning of MeOH in one of its Pratt and Whitney FT4C-1 Turbines. The existing storage facilities for No. 2 oil would be compatible with MeOH storage, although some expansion would be necessary.

There has been considerable interest in the use of MeOH as a blend with gasoline in automobiles. Reports show the possibility of cleaner burning and higher efficiencies than are obtainable from gasoline fuels. At present, MeOH is chiefly used as a chemical feedstock for a variety of products. Most methanol produced in the United States has been synthesized from natural gas by standard methods since the 1920's. Methanol is being viewed as an economically feasible way of utilizing remote (overseas) natural gas supplies.

Because of methanol's continued importance as a chemical feedstock and its potential application as a gas turbine and automotive fuel, the production of MeOH was considered as a promising candidate alternative. Not only can MeOH be produced from coal and MSW, but essentially from any substance containing carbon. In addition to its use as an alternative fuel, methanol is reported to be useful in the denitrification of some municipal wastewaters. This feature plus its clean burning characteristics indicate that its expanded use would be welcomed by the environmentalists. MeOH was not considered an appropriate fuel for base-load power plants for the same reason syngas was rejected; namely, coal Btu prices are quite low. No. 2 oil Btu prices are projected to rise to levels which will make MeOH quite competitive.

e. Production of a Gaseous Feedstock for Ammonia Synthesis

TVA's National Fertilizer Development Center at Muscle Shoals, Alabama, conducts the nation's only comprehensive fertilizer research and development program. Its activities are broad in scope, including basic fertilizer chemistry research, pilot plant investigation, greenhouse and field testing, semicommercial production facilities and technical and economic assistance to both established and potential producers. The Center's impact is nationwide and is achieved through cooperative educational and development programs with farmers, extension workers, educators and members of the fertilizer industry.

In 1974, TVA produced 74,000 tons of anhydrous ammonia for its fertilizer programs. TVA has projected that this production will remain constant through 1980. TVA's 250-ton-per-day ammonia plant at Muscle Shoals, Alabama, uses natural gas as feedstock. The ammonia produced serves as input material for a variety of nitrogen fertilizers. It is estimated that the solid waste generated in the Huntsville, Alabama, region alone would be sufficient to serve as feedstock for gasification in a 250-ton-per-day ammonia plant.

To be a viable alternative, it would be necessary to produce the synthetic gas in the same location as the ammonia. Huntsville is located only 60 miles east of Muscle Shoals. The shipment of the Huntsville organic material to Muscle Shoals for processing into a gas was considered worthy of further study. The gaseous products from MSW could provide a substitute feedstock for natural gas which is in great demand for residential heating; and this function can take priority over its use in fertilizer manufacture.

Ammonia plants, like many other chemical operations, are essentially around-the-clock, 7-day-per-week operations. Shutting them down is expensive, but with an insecure feedstock such as natural gas, intermittent operation may become more prevalent. Syngas from MSW could provide a secure feedstock for a TVA ammonia plant. Thus, economics is but one of several parameters which must be assessed.

Both nationally and throughout the world, ammonia-based fertilizers are in critically short supply. A large-scale demonstration project to prove out a new gaseous feedstock for ammonia production could have significant impact in this area. If the gaseous feedstock were produced from solid waste, only a limited amount of ammonia could be produced due to practical limitations on the supply of waste in the vicinity of a specific plant. However, if both solid waste and coal were considered as potential source material for producing syngas for ammonia production, the practical limit on fertilizer production would be removed. Ammonia production costs are discussed in the IEA report as are comments for integrating ammonia production into a TVA energy program.

Gasification and Alternative Uses of Syngas

As a result of reviewing each potential gasification alternative based on the Selection Criteria previously discussed, methanol and ammonia were singled out as attractive possibilities for further study. An economically viable source of methanol could provide TVA with a method of eliminating its dependence on oil for a portion of its power production.

Regardless of whether methanol or ammonia is to be produced from solid waste, production of a gaseous feedstock is a necessary prerequisite. As this gaseous feedstock would be produced from the organic portion of the solid waste, both methanol and ammonia synthesis are relatively indifferent to and therefore compatible with recovery and recycling of material from the inorganic waste fraction. No attempt was made by IEA to analyze the technical or economic feasibility of either solid fuel production from the organic waste fraction or recovery of materials from the inorganic fraction. These processes are discussed elsewhere in this report.

The Ralph M. Parsons Company was retained to investigate several waste gasification concepts and to select one as optimum for production of an ammonia or methanol from the resulting syngas. The Parsons Company also provided cost estimates for each system investigated.

Selected Gasification Process

Systems reviewed by the Ralph M. Parsons Company included the following:

1. Monsanto Landgard System, St. Louis
2. Torrax System, Carborundum Corporation, New York
3. Pyrotek System, California
4. Battelle Northwest System, Washington
5. Barber-Coleman System, California
6. Union Carbide Corporation Purox System, New York

The Union Carbide Corporation's Purox System was selected as the one which appeared to be closest to commercial scale operation, combined with a process which was environmentally acceptable and compatible with ammonia and methanol process requirements. The IEA report presents a detailed discussion of each system.

Cases Considered

Thirteen variations, or cases, were investigated for a resource recovery system, one of whose products might be methanol or ammonia. These cases are discussed in the IEA report. All cases were compatible with the concept of recovering and recycling the metals and glass from the inorganic waste fraction.

Table 12-1 illustrates the variety of system configurations reviewed. While some cases (5, 6, 10B, and 10C) produced only methanol; others resulted in methanol and solid fuel (1, 2, 3, and 4); some cases produced methanol, solid fuel and ammonia (8, 9, and 10; and yet others resulted in methanol and ammonia production (7 and 10A).

Economic Assessment

In order to determine the costs of a resource recovery system producing either methanol or ammonia, it was necessary to determine the cost associated with the following functions:

1. Transportation of municipal solid waste to processing plant(s).
2. Conversion of solid waste into either methanol or ammonia.
3. The transportation of methanol to specific gas turbine, installations, (NOTE: No distribution costs were determined for ammonia as all cases involved process plants located at Muscle Shoals, with the ammonia produced serving as feedstock to the existing fertilizer manufacturing complex located there.)

Table 12-1

CASES VS. ALTERNATIVE FUNCTIONS

Location	Function* vs. Case 1	2	3	4	5	6	7	8	9	10	10A	10B	10C
Tri-Cities	S	TS	TS	TS	TS	TS	TS	TS	S	S	TS	TS	TS
Knoxville	M	M	S	M	M	M	M	M	M	TS	TS	TS	TS
Asheville	S	TS	TS	TS	TS	TS	TS	TS	S	S	TS	TS	TS
Chattanooga	M	S	TS	M	TS	TS	M	S	M	TS	TS	TS	TS
Huntsville	S	S	M	S	M	M	TS	TS	TS	TS	TS	TS	M
Watts Bar	-	-	-	-	-	-	-	-	-	M	M	M	M
Muscle Shoals	-	-	-	-	-	-	A	A	A	A	A	-	-
Allen	$\underline{M}$	-	-	-	$\underline{M}$	-	-	-	$\underline{M}$	$\underline{M}$	-	-	-
Colbert	$\underline{S}$	$\underline{MS}$	$\underline{M}$	$\underline{S}$	$\underline{M}$	-	-	M	-	-	-	-	-
Gallatin	-	$\underline{M}$	-	$\underline{M}$	-	-	$\underline{M}$	-	-	-	$\underline{M}$	-	-
Johnsonville	-	-	-	-	-	$\underline{M}$	-	-	-	-	-	$\underline{M}$	$\underline{M}$
Bull Run	-	-	-	-	-	-	-	-	$\underline{S}$	$\underline{S}$	-	-	-
Kingston	$\underline{S}$	$\underline{S}$	$\underline{S}$					$\underline{S}$					

*S - Solid Fuel Plant, $\underline{S}$ - Solid Fuel User

M - Methanol Plant, $\underline{M}$ - Methanol User

A - Ammonia Plant, TS - Regional Transfer Station

$\underline{MS}$ - Methanol and Solid Fuel User

It was assumed, for purposes of the study, that solid waste would be transported to the methanol processing plant via the same system envisioned for a solid fuel processing plant, i.e., by a combination of trucks and railcars. It was further assumed that methanol would be transported to using locations via a towboat/barge-tanker fleet as all using locations and prospective processing plants are located on navigable waterways.

It was furtherassumed, for purposes of the study, that TVA would own and operate the elements of the transportation system for both waste and methanol; TVA would own and operate the processing plants and would buy the fuel product in its entirety for its power operations at actual cost.

As a result of evaluating the 13 cases, Case 10B was selected as offering themost cost-effective methanol product. Case 10B (See Table 12-1) would call for a processing plant at the Watts Bar Steam Plant. The solid wastes from Asheville, North Carolina, the Tri-Cities, Tennessee area, Knoxville, Chattanooga, and Huntsville would be transported to this location for conversion to methanol. From Watts Bar, the methanol would be brought to Johnsonville, where it would be stored until needed for power production. All cost estimates which follow are representative of this case.

The Ralph M. Parsons Company on contract to IEA made cost estimates for plants of four different daily capacities of 933, 1,867, 2,800, and 3,848 TPD of incoming MSW. These cost estimates are shown in Table 12-2.

To ensure that these cost estimates were comparable to those estimates used in producing a fuel for utility boilers, TVA used the Parsons numbers to prepare Table 12-3. Table 12-3 uses the same format as other estimates in this report.

The following represents the capital costs associated with various elements of a resource recovery system which would process approximately 3,850 tons of waste per day and convert it to methanol:

(1) MSW Transportation - $41,000,000

The transportation system required to move 3,848 tons of MSW from five waste centers to a Watts Bar MeOH processing plant would consist of the following: 108 transfer-trailers ($2,500,000), 44 tractors ($1,400,000), 5 regional transfer stations ($23,000,000; 1 at $3,600,000, 2 at $4,500,000, 2 at $5,200,000, see Table 605), 352 roto-discharge hopper cars ($13,000,000) and a car cleaning and dispatch facility ($1,200,000).

(2) Methanol Processing - $161,000,000

This cost includes $56,000,000 (See Table 7-6) for a MSW plant which recycles ferrous, aluminum, glass, and nonferrous material

TABLE 12-2 CAPITAL COSTS (1974 $)

	*Plant Size (T/D of MSW)			
Cost Element	933	1867	2800	3848
Basic Syngas Plant ($\$10^6$) Capital Equipment - Construction				
(a) Buildings	1.659	3.119	3.958	
(b) Site Improvement	0.125	0.182	0.182	
(c) Material Handling Equipment	0.698	1.272	1.572	
(d) Supporting Facilities	0.627	0.820	0.959	
(e) Pilings, Equipment Pads, etc.	0.377	0.572	0.572	
(f) Oxygen Plant	4.784	7.252	10.702	
(g) Purox Converter Plant	4.100	8.080	11.753	
Subtotal - Construction Cost	12.370	21.297	29.698	38.00**
Spare Parts Inventory	0.278	0.483	0.693	0.89
Contingency	1.407	2.618	3.518	4.50
Engineering and Construction Management	1.007	1.373	1.860	2.38
Subtotal	15.062	25.768	35.769	45.77
Working Capital	0.340	0.582	0.808	1.03
Startup Costs	0.660	1.129	1.567	2.01
Interest During Construction (9½% - 2½ years)	0.816	1.396	1.938	2.48
Total Cost - Basic Syngas Plant	16.878	28.875	40.082	51.29

*Source: Ralph M. Parsons Company for 933, 1867 & 2800 T/D plants. Parsons' data extrapolated to estimate 3848 T/D costs.

**No attempt made to estimate cost of individual items of equipment and facilities.

TABLE 12-2 CAPITAL COSTS (1974 $)
(cont.)

Cost Element	*Plant Size (T/D of MSW) 933	1867	2800	3848
Syngas Delivery ($10^6)				
Basic Syngas Plant	15.062	25.768	35.769	45.77
Add:				
Pumping Station	1.320	2.000	2.000	2.70
Spares	0.053	0.080	0.080	0.11
Pipeline				
Contingency at 25%	0.343	0.520	0.520	0.68
Engineering and Construction Management at 10%	0.137	0.208	0.208	0.27
Subtotal	16.915	28.577	38.577	49.53
Working Capital	0.382	0.646	0.871	1.12
Startup Costs	0.741	1.252	1.690	2.17
Interest During Construction (9½% - 2½ years)	0.916	1.548	2.090	2.68
Total Cost Syngas Delivery	18.954	32.023	43.228	55.50

*Source: Ralph M. Parsons Company for 933, 1867 & 2800 T/D plants. Parsons' data extrapolated to estimate 3848 T/D costs.

TABLE 12-2 CAPITAL COSTS (1974 $)

(cont.)

Cost Element	*Plant Size (T/D of MSW) 933	 1867	 2800	 3848
Methane (SNG) ($$10^6$)				
Basic Syngas Plant	15.062	25.768	35.769	45.77
Add:				
Methanation Plant	4.311	6.534	8.000	9.38
Spares	0.177	0.261	0.320	0.38
Contingency at 15%	0.673	0.980	1.200	1.41
Engineering and Construction Management at 10%	0.449	0.653	0.800	0.94
Subtotal	20.672	34.196	46.089	57.88
Working Capital	0.467	0.773	1.041	1.31
Startup Costs	0.906	1.498	2.019	2.54
Interest During Construction (9½% - 2½ years)	1.120	1.852	2.497	3.14
Total Cost Methane (SNG) Production	23.165	38.319	51.646	64.87

*Source: Ralph M. Parsons Company for 933, 1867 & 2800 T/D plants. Parsons' data extrapolated to estimate 3848 T/D costs.

TABLE 12-2 CAPITAL COSTS (1974 $)
(cont.)

Cost Element	*Plant Size (T/D of MSW) 933	1867	2800	3848
Electric Power ($$10^6$)				
Basic Syngas Plant	15.062	25.768	35.769	45.77
Add:				
Electric Power Plant	5.425	10.850	16.280	22.40
Spares	0.217	0.434	0.651	0.90
Contingency at 15%	0.814	1.628	2.442	3.36
Engineering and Construction Management at 5%	0.282	0.543	0.814	1.12
Subtotal	21.800	39.223	55.956	73.55
Working Capital	0.492	0.886	1.260	1.66
Startup Costs	0.955	1.718	2.451	3.22
Interest During Construction (9½% - 2½ years)	1.181	2.125	3.031	3.99
Total Cost Electric Power Production	24.428	43.952	62.698	82.42

*Source: Ralph M. Parsons Company for 933, 1867 & 2800 T/D plants. Parsons' data extrapolated to estimate 3848 T/D costs.

TABLE 12-2 CAPITAL COSTS (1974 $)

(cont.)

Cost Element	*Plant Size (T/D of MSW) 933	1867	2800	3848
Methanol ($\$10^6$)				
Basic Syngas Plant	15.062	25.768	35.769	45.77
Add:				
Methanol Plant	7.125	10.800	13.770	16.67
Spares	0.285	0.434	0.551	0.66
Contingency at 15%	1.111	1.620	2.066	2.50
Engineering and Construction Management at 5%	0.356	0.540	0.689	0.84
Subtotal	23.939	39.162	52.845	66.44
Working Capital	0.541	0.884	1.194	1.50
Startup Costs	1.049	1.716	2.315	2.92
Interest During Construction (9½% - 2½ years)	1.297	2.121	2.863	3.60
Total Cost Methanol Production	26.826	43.883	59.217	74.46

*Source: Ralph M. Parsons Company for 933, 1867 & 2800 T/D plants. Parsons' data extrapolated to estimate 3848 T/D costs.

TABLE 12-2 CAPITAL COSTS (1974 $)

(cont.)

	*Plant Size (T/D of MSW)			
Cost Element	933	1867	2800	3848
Ammonia ($10^6)				
Basic Syngas Plant	15.062	25.768	35.769	45.77
Add:				
Ammonia Plant	10.231	15.500	19.771	23.92
Spares 4%	0.409	0.620	0.791	0.96
Contingency at 15%	1.535	2.330	2.966	3.587
Engineering and Construction Management at 5%	0.512	0.775	0.989	1.196
Subtotal	27.749	44.993	60.286	75.433
Working Capital	0.626	1.016	1.362	1.71
Startup Costs	1.215	1.971	2.642	3.31
Interest During Construction (9½% - 2½ years)	1.503	2.437	3.265	4.09
Total Cost Ammonia Production	31.093	50.417	67.555	84.54

*Source: Ralph M. Parsons Company for 933, 1867 & 2800 T/D plants. Parsons' data extrapolated to estimate 3848 T/D costs.

TABLE 12-3

TVA Estimate of a Syngas - Methanol Production Plant

	Amount ($000's)
Basic Syngas Plant	
Equipment, Buildings, Etc.	$ 38,000
Spare Parts	890
	38,890
Pumping Station	
Equipment and Structure	2,700
Spare Parts	110
Methanol Plant	
Equipment, Buildings, Etc.	16,670
Spare Parts	660
	17,330
Total Construction Cost	$ 59,030
Engineering Design	2,300
Manger's Office - OEDC	260
CSB - Engineering Group	80
Personnel	100
Purchasing	200
Medical Services	150
Employee Compensation Benefits	850
Finance	160
A&G	730
Contingency Allowance	9,140
Interest During Construction	7,000
Total Project Cost (1974 Prices)	$80,000
Total Project Cost (1977 Prices)	105,000

The total costs shown above are based on construction costs developed by Ralph M. Parsons Company (see Table 12-2) for a plant sized to process 3848 tons of incoming MSW per day. TVA costs are added including general expense, contingency, and interest during construction. Costs were also escalated to 1977 dollars.

from 3,848 T/D of MSW in the same manner as a solid fuel processing plant. In addition, this plant will prepare the MSW for gasification unlike its counterpart, which would perform additional functions in order to produce solid fuel.

The $161,000,000 figure also includes $105,000,000 (See Table 12-3) for a basic syngas plant, methanol synthesis plant, and pumping station.

(3) Methanol Transportation - $2,100,000

This cost includes approximately $1,700,000 for six barge-tankers and $400,000 for a towboat. One of the barge-tankers would normally be on a standby basis.

(4) Gas-Turbine Modifications - $9,800,000

This estimate includes the cost of modifying the 16-67.8 MW General Electric gas turbines at Johnsonville to burn methanol at an approximate cost of $610,000 each.

(5) Additional Storage Capacity - $700,000

Approximately 6.5×10^6 gallons of additional fuel storage capacity would be required to accommodate the use of methanol at anticipated demand. This additional storage would supplement the present 23×10^6 gallons.

An economic comparison was made of both the solid fuel concept, and the gasification with subsequent methanazation and gas turbine utilization concept. Amortization periods of 10, 15, and 20 years were considered. Results of this comparison are shown in Figures 14-1 through 14-2 in the last section of this report.

SECTION XIII

ENVIRONMENTAL ASSESSMENT

This section of the report was prepared by the Division of Environmental Planning.

General Environmental Considerations

The underlying purposes of resource recovery are to reduce the adverse environmental impacts associated with conventional solid waste practices, to conserve natural resources, and to develop additional sources of energy. The environmental feasibility must be assessed in terms of the favorable benefits derived from such a project and balanced against the added stresses or impacts caused by the system's operation. Environmental benefits are possible through reduced land disposal requirements, the recycling of secondary materials into the market system, and the development of additional sources of energy. Adverse impacts associated with the operation of a resource recovery system include the consumption of fuels for transportation and processing, the pollutants caused by the transportation system, and the secondary pollutants and stresses created by recovering the waste and utilizing the fuel product. Most of the anticipated impacts that endanger the environment are controllable and are regulated by Federal and state legislation.

Major Environmental Benefits

The establishment of a full-scale resource recovery system in the TVA power service area would allow over 70 major landfills in the region to reduce their operations by at least 80 percent. Most landfills would be maintained as a backup for the regional system and would normally receive only construction and demolition materials and some industrial wastes. The problem normally experienced by landfills would be either eliminated or significantly reduced.

Depending upon the final use of the fuel product (coal supplement, gasification, or conventional incineration with heat recovery), the annual energy supply developed from the regionwide system would be equivalent to 960,000 tons of coal. In terms of TVA's coal-fired electrical generation, processed fuel from solid waste would supply approximately two percent of the demand. Some energy savings would be possible from the introduction of secondary metals such as ferrous and aluminum scrap into the metals processing industry.

Major Environmental Costs

One of the most significant undesirable impacts on the environment is the energy costs resulting from the transportation network serving the resource recovery system. The fully developed system would result in an additional 6.1 million truck miles, and 210,000 train miles annually. Therefore, the increase in annual fuel consumption for the increased handling of MSW over present methods would be approximately 1.8 million gallons of diesel fuel. This is two percent of the total energy available from the solid waste derived fuel.

Environmental Evaluation

The collection and transportation of MSW creates potential environmental problems in the areas of employee health and safety, air quality and water quality. Loading and unloading areas will have to be strictly controlled to eliminate dust in the working environment. An effort should be made to control noise to avoid adverse effects on employees and to avoid a nuisance to the public. If noise levels exceed established standards, protective equipment will be required for employees. In order to prevent the loss of lightweight material, it will be necessary to transport the MSW in essentially sealed transfer containers. Under these conditions, the MSW will become odoriferous in 24 to 48 hours. For this reason, it is imperative that there be a minimum of delay in transporting the MSW to the processing plant. The odor produced when excessive transportation time is required not only creates an undesirable work environment but is accompanied by an increased potential for employee exposure to pathogenic microorganisms, intestinal parasites, and bacteria.

In order to reduce potential harmful effects on air quality, engines in all transfer vehicles should be properly tuned, and where practical, the use of diesel powered engines is recommended.

The loading and unloading operations must be strictly controlled to eliminate the possibility of either solids or liquids in the MSW escaping into surface streams. All surface runoff from the transfer stations and truck aprons and washdown water from the facility and equipment must be treated in accordance with EPA guidelines pursuant to the Federal Water Pollution Control Act before discharge into surface streams. An NPDES permit will be required for these discharges.

In the gasification concept, the transportation of methanol by barge causes a potential water quality problem in the loading and unloading process. Adherence to standard loading and unloading procedures will help eliminate the possibility of contamination by spillage.

The processing, handling, and storage of MSW creates numerous effects on the health and safety of employees. Typical municipal solid waste contains human excrement, including sputum and other nasopharyngeal discharges, and fecal solids for humans (disposable diapers) and animals (pets). These wastes comprise a relatively small percentage of the total volume; however, they are potentially serious health hazards to employees. Close medial supervision of employees will be required. Employees may also be exposed to dust containing toxic or sensitizing chemical constituents and pathogens. Efforts must be made to control dusting and dust and skin contact with dust must be minimized. The use of flotation as a means of waste separation is being considered. The handling of the flotation reagents may be a health and safety problem, depending upon the technology selected.

Provisions must be made to protect employees from possible detonation of explosive substances that may be included in the MSW. The greatest hazard exists in the vicinity of the breaking and shredding equipment. This equipment must be designed to contain or suppress small explosions of this type, and personnel should normally be excluded from these areas during operation.

Adequate lighting, noise control, heating and cooling, and sanitary facilities, including showers, water closets, washbasins, and drinking fountains, must be provided. Protective equipment may also be required in this phase if noise levels are sufficiently high.

The principal air quality problem associated with the processing plant is dust. All processing plant ventilation system discharges must be equipped with filters maintained to reduce emissions of airborne dust.

As with the transfer station, all runoff and washdown water from the processing plant must be treated prior to discharge. If sanitary sewers are available, the sanitary wastes can be discharged directly into them, but depending upon local regulations, other wastewater may require pretreatment before discharging into the sewers.

The principal industrial hygiene problem at plants utilizing SWDF as supplement to coal is that of the pressurized boilers leaking combustion gases into the plant work environment. No increase in concentrations of SO_2 and NO_x is expected with the addition of SWDF. Present concentrations of NO_x are unknown and concentrations of SO_2 are thought to be excessive at times without the use of SWDF as a supplemental fuel. Present concentrations of fly ash and HCl also are unknown, but due to the composition of the SWDF, fly ash concentrations are expected to increase and HCl concentrations may increase. The physiological effect of exposure to coal combustion gases containing SO_2, NO_x, hydrochloric acid (HCl), and fly ash on employee health has not been determined; however, since these gases act as primary tissue irritants on inhalation, their toxicological effect would be expected to be additive, and a correspondingly reduced permissible exposure would apply.

Heat and noise levels in the boiler bays are not expected to increase above existing levels when SWDF is introduced. These are occasionally excessive now, hearing protection is provided in these areas where noise is a problem.

Industrial hygiene problems in the gasification and methanol synthesis processes are not expected to be significant. Modern designs take into consideration potential hazards to personnel and to the environment and should eliminate any problems. However, methanol is both an irritant and a central nervous system depressant. Precautions should be taken to assure that personnel who may come in contact with it in the course of their jobs are aware of its potential toxicity.

A preliminary assessment was made of the impact on air quality at Colbert and Widows Creek Steam Plants. The Colbert location, in rolling terrain, provides better dispersion for stack gas emissions than the Widows Creek location, which is bounded on the south by Sand Mountain; however, no negative impacts are expected to occur at Widows Creek. At each location, burning the combined fuel (which is expected to have a lower sulfur content than coal alone) at the projected rate of 10 percent of the Btu input to the boiler may lower SO_2 and NO_x concentrations in the stack gas.

At Cumberland, Kingston, and Bull Run Steam Plants, burning combined fuels containing 10 percent SWDF should not cause a significant adverse change in SO_2 or NO_x emission or ambient concentrations; however, particulate emission standards would likely be exceeded at Cumberland.

At Kingston and Bull Run Steam Plants the new electrostatic precipitators have a safety margin incorporated into their design efficiencies that might tolerate some increase in particulate inlet loading. However, with more than 10 percent solid waste derived fuel, the particulate emission standards are also likely to be exceeded at these plants; if so, suspended particulate concentrations in excess of ambient standards may result. Poor community relations in the Bull Run vicinity due to insufficient particulate emission control could be aggravated should any additional TVA activity be contemplated for the area. Therefore, the potential of an adverse impact on community relations should be considered in making the decision to implement this project at the Bull Run Steam Plant.

Air quality is not expected to be a problem with the gasification-methanol concept. Gaseous wastes from the gasification and methanol synthesis processes are primarily carbon dioxide which is not considered a pollutant and therefore creates no problem. It should also be noted that the use of methanol as a gas turbine fuel would create less impact on air quality than the use of number 2 fuel oil.

Ground and surface waters at or near the plants burning SWDF are not expected to be adversely affected. However, a routine ground and surface water monitoring program would have to be developed to identify any changes in the quality of this water.

There is a question concerning the applicability of EPA's August 14, 1974, "Thermal Processing and Land Disposal Guidelines," in disposing of the combined SWDF and coal ash residue. Under this proposal, the combustible fraction of the processed solid waste would be burned as a supplemental fuel in selected coal-fired, steam-electric generating plants with the SWDF comprising only 10-20 percent of the gross Btu input to the boiler. Present studies indicate that the residue should be inert and could be discharged to existing ash ponds.

EPA indicated in a letter dated May 7, 1975, Darnay to Dr. Krenkel, that the guidelines would apply to the fuel supplement-type systems under consideration, although the extent of their applicability would be "judgemental" because at the time the guidelines were written these systems had not "matured sufficiently to be included by specific reference." Darnay did indicate that the guidelines were intended to be "flexible" and their intent is "that the environment be protected." Darnay's letter stated that EPA's main concern is with residual organics and toxic chemicals that may be leached from the residue and enter the surface and ground waters.

Our own interpretation of the guidelines is that they were intended to be restricted to more conventional incineration facilities whose purpose is to thermally process 50 tons per day or more of MSW, and that they should not be read to require landfilling of the combined residues of a fuel supplement-resource recovery system. However, we do agree with the main point of Darnay's letter: residues must be disposed of in an environmentally acceptable manner. The legal question of guideline applicability has not been resolved.

EPA has made an offer for cooperative work on the question of harmful leachate from combined residue and ash disposal in steam plant ash ponds. The Division of Environmental Planning will make the necessary arrangements with EPA for this study at the appropriate time. Should additional study indicate that there will be incomplete combustion resulting in a high organic content in the residue, additional measures possibly including some form of landfilling may be required. An estimate of landfilling cost under the EPA guidelines at Cumberland, Bull Run, and Kingston Steam Plants has been prepared. These estimates are as follows.

Steam Plant	Capital Cost	Annual Operating Cost
Cumberland	3,100,000	1,100,000
Bull Run	1,200,000	500,000
Kingston	1,600,000	600,000

The magnitude of these costs emphasizes the necessity of providing a good, clean SWDF and of making proper boiler modification to ensure complete combustion.

Disposal of residue in the gasification concept is not of as much concern as in the solid fuel concept. Residue produced in the processing plant need not be separated and landfilled at this point, it can remain with the flue fraction through the combustion process and be handled with the residue from this process. The residue from this process is a completely inert glassy frit which does not require disposal in a sanitary landfill. This will cut the cost of landfilling associated with the project considerably. It may even be possible to create a market for this residue.

Environmental Compliance

The following is a list of Federal laws that are applicable to this project.

1. Solid Waste Disposal Act, as amended
2. Federal Water Pollution Control Act, as amended
3. Clean Air Act, as amended
4. Occupational Safety and Health Act, as amended
5. Noise Control Act, as amended
6. Federal Insecticide, Fungicide and Rodenticide Act, as amended

Executive Order 11752 requires that Federal agencies comply with guidelines to be issued by the Administrator (EPA) pursuant to the Solid Waste Disposal Act, as amended, concerning solid waste recovery, collection, storage, separation, and disposal systems. Only one of these, "Thermal Processing and Land Disposal of Solid Waste Guidelines (August 14, 1974, and February 4, 1975)," has been issued to date.

These guidelines require that effluents and emissions from thermal processing facilities and land disposal sites meet the most stringent water and air quality standards of local, state, interstate, or Federal regulations. The guidelines require that pertinent provisions of the Occupational Safety and Health Act of 1970 and regulations promulgated thereunder apply to processing and land disposal systems. Disposal of pesticides and pesticide containers on Federal property or processing of pesticides and pesticide containers in Federal facilities shall be consistent with the Federal Environmental Pesticides Control Act of 1974 and recommended procedures promulgated thereunder.

Contacts are being made with EPA regarding the possibility of relaxing air emission standards for utility boilers burning SWDF as a supplemental fuel. EPA has already ruled that utility boilers burning SWDF are not subject to the New Source Performance Standards.

In addition to these laws and regulations, pertinent sections of the Noise Control Act of 1972 and Executive Order 11807 will apply to all phases (collection, transportation, processing, and disposal) of a resource recovery system. Compliance with Office of Management and Budget Circular A-106 will also be required.

Municipal solid waste processing facilities constructed on TVA property, sold to the processor, and operated by the processor or his agent must comply with TVA deed restrictions, with Section 26a of the TVA Act of 1933, and with Federal, state, and local laws.

SECTION XIV

OVERALL ECONOMIC ASSESSMENT

To evaluate the economics of burning a solid waste-derived fuel produced from a regional resource recovery system in a conventional coal-fired boiler, it was necessary to choose a TVA steam plant to complete this evaluation. Economic studies were made of the six TVA steam plants in the eastern part of the Tennessee Valley Region and these investigations indicated that the highest net price could be paid for solid waste-derived fuel at the Bull Run Steam Plant. The higher net price is due to Bull Run being a large, fairly new coal-fired unit which has a high capacity factor. Bull Run was chosen for this evaluation although the use of solid waste-derived fuel at the Bull Run Steam Plant is not recommended due to environmental consequences and the lack of flexibility at a single unit plant. To present the economics associated with burning of solid waste-derived fuel in a conventional coal-fired boiler, Figures 14-1 through 14-9 were prepared using data and estimates from this feasibility study. To present the economic evaluation associated with the production of methanol from refuse, Figures 14-10 through 14-12 were prepared using data and estimates from this feasibility study.

The economic operation of TVA's power system is achieved by a method called economic dispatch. The optimum economic condition is reached by using these generating units with the lowest incremental cost to supply the system's energy requirements each hour. The selection of the units to supply energy for the system load is based upon the restraints in the generating plant and on the transmission network.

When a commitment is made to burn refuse, the units burning refuse may be required to remain in operation when other units of lower incremental costs would be selected by the economic dispatch system. The difference in the cost of operation for the units burning refuse and the lower cost units is called the economic dispatch penalty.

We have estimated the economic dispatch penalty by using computer programs to simulate the operation of the TVA power system and assigning the generation required to the plants with the lowest incremental costs. Basic studies were made with no plants committed to burn refuse. Then additional studies were made with different plants committed to burn refuse. The differences in total system production costs were used to determine the estimated annual increase in system production costs when the plant was committed to burn refuse.

The present value of these system production cost differences, in 1977 dollars, was used to estimate the cost in dollars per ton of solid waste collected for the economic dispatch penalty over the life of the project.

The estimates of capital investments required for the transportation equipment, transfer stations, and processing plant and at the steam plants for refuse receiving and storage, pneumatic transport, and burner modifications were prepared by OEDC. These cost estimates were used as investments that would be recovered over the estimated project life with an interest rate of 8½ percent per annum. The amortization was used to estimate the costs in dollars per ton of solid waste collected for the required capital investments.

When solid waste-derived fuel is burned in a power boiler, there is a reduction in the amount of coal required for the unit. Also, there may be a reduction in boiler efficiency due to the moisture and ash content of the refuse. The refuse has a gross fuel value in proportion to the amount of coal that it would replace. We have used estimated coal costs for each year of the life of the project and the BTU content of the refuse delivered to the plant each year to determine the fuel values. The present value of these annual fuel costs was expressed in 1977 dollars using the present worth factors for each of the years based on an interest rate of 8½ percent per annum.

The ferrous scrap aluminum scrap, glass, and other metals that will be recovered in the processing plant will have some market value. TVA advertised for bids on these items to determine the current interest in purchasing reclaimed scrap metals and glass from municipal solid waste. We used the bid information and other market data to estimate a current price for ferrous metals and alluminum. These values were escalated at a rate of 5½ percent per annum to obtain current values for use in each year of the project life. The present value of the reclaimed metals was estimated using the annual values for each year of the project life and an interest rate of 8½ percent per annum. Capital recovery factors for 10, 15, and 20 years and the estimated annual tons of solid waste to be collected each year were used to determine an estimated value in dollars per ton of solid waste collected for the life of the project.

Figure 14-1 shows the costs, incomes, and net in 1977 dollars for a system which processes approximately 14,000 tons per week of refuse in five days using a two-shift operation. The systems produce approximately 7,600 tons per week of solid waste-derived fuel which is burned at the rate of approximately 1,080 tons per day. The major capital costs associated with this system are $54,000,000 for a processing plant, which includes a car dumper located at a nonspecific site, and $25,500,000 for modifications, feed systems, and 2,000 tons of storage at the power plant site. The $54,000,000 was developed in a comparative estimate and, therefore, does not reflect the same degree of accuracy as the $35,000,000 estimate for a processing plant. To prepare this figure, it was assumed that capital costs would be depreciated over a 10-year period with an interest rate of $8\frac{1}{2}$ percent and a salvage value of zero at the end of the 10-year period. For this case the net is a minus $17.10 per ton of refuse being processed. To avoid impacting electric rates of the TVA system, it is required that $17.10 per ton or approximately $12,400,000 per year of 1977 dollars be obtained from other than Power funds in F.Y. 1980-1989.

In developing Figures 14-2 and 14-3, the assumptions and estimates are the same as those used to develop Figure 14-1, except that for Figure 14-2 the time period is 15 years, while for Figure 14-3 the time period is 20 years. For the 15-year period (F.Y. 1980-1994), it is required that $13.20 per ton or approximately $9,600,000 per year of 1977 dollars and for the 20-year period (F.Y. 1980-1999), $11.40 per ton or approximately $8,300,000 per year of 1977 dollars be obtained from sources other than power funds to avoid an increase in electric rates.

Figure 14-4 shows the costs, incomes, and net in 1977 dollars for a system which processes approximately 14,000 tons of refuse per week in 7 days using a two-shift operation. This system provides approximately 1,080 tons of solid waste-derived fuel per day to be burned at the same rate. The major capital costs associated with this system are $35,000,000 for a nonspecific site, without a car dumper, processing plant and $17,000,000 for modifications, feed system, receiving system, and 1,000 tons of storage at the steam plant. Other comparative estimates were made for processing plants which are shown on this figure. The $36,000,000 processing plant includes a car dumper and is located at a specific site, and the $38,000,000 processing plant includes a car dumper and is located at a nonspecific site. The considerations are time period of 10 years, interest rates of $8\frac{1}{2}$ percent, and capital costs completely depreciated in the 10-year period. To ensure that the cost of electricity is not increased, it is required that $11.40 per ton or approximately $8,300,000 per year of 1977 dollars be obtained from other than power funds F.Y. 1980-1989 for the system using the $35,000,000 processing plant.

In developing Figures 14-5 and 14-6, the assumptions are the same as those used to develop Figure 14-4, except that for Figure 14-5 the time period is 15 years, while for Figure 14-6 the time period is 20 years. For the 15-year period (F.Y. 1980-1994), it is required that $8.20 per ton or approximately $6,000,000 per year of 1977 dollars and for the 20-year period (F.Y. 1980-1999), $7.50 per ton or approximately $5,500,000 per year of 1977 dollars be obtained from sources other than power funds to avoid an increase in electric rates for the system using a $35,000,000 processing plant.

Figure 14-7 uses the same estimates and assumptions as those used for Figure 14-4, except the costs of modification at the power plant which would provide for minimum storage is $14,000,000. To avoid an impact on power rates would require that $10.70 per ton or approximately $7,800,000 per year of additional income of 1977 dollars be acquired from sources other than power funds for the system using a $35,000,000 processing plant.

In developing Figures 14-8 and 14-9, the assumptions are the same as those used to develop Figure 14-7, except that for Figure 14-8, the time period is 15 years, while for Figure 14-9 the time period is 20 years. For the 15-year period (F.Y. 1980-1994), it is required that $8.20 per ton or approximately $6,000,000 per year of 1977 dollars and for the 20-year period (F.Y. 1980-1999), $7.00 per ton or approximately $5,100,000 per year of 1977 dollars be obtained from sources other than power funds to avoid an increase in electric rates for the system using a $35,000,000 processing plant.

Figure 14-10 shows the costs, incomes, and net in 1977 dollars for a system which processes approximately 27,000 tons per week of refuse at 7 days per week around-the-clock operation. This system produces approximately 1,500,000 gallons of methanol per week which can be burned or stored in tanks. The major capital costs associated with this system are $56,000,000 for a processing plant and $105,000,000 for a gasification plant and a plant to convert the gas to methanol. The interest rate used is $8\frac{1}{2}$ percent. For this case, the net is a minus $17.50 per ton of refuse being processed. To avoid an impact on power rates would require that $17.50 per ton or approximately $24,600,000 per year of additional income of 1977 dollars be acquired from sources other than power funds.

In developing Figure 14-11, the same assumptions as used to develop Figure 14-10 apply, except the time period used was 15 years. Since the net for this case is also negative $12.00 per ton, it is required that other funds in the amount of $12.00 per ton or approximately $16,800,000 per year in 1977 dollars be acquired or power rates will increase.

In developing Figure 14-12, the same assumptions as used to develop Figure 14-10 apply, except the time period used was 20 years. The net for this case is a negative value of $11.00 per ton which would amount to approximately $15,400,000 per year in 1977 dollars. For this case, there is no impact on power rates.

To illustrate the impact which interest rates could have on a resource recovery system, Figure 14-13 and 14-14 were prepared. For an interest rate of $8\frac{1}{2}$ percent in Figure 14-13, the numbers shown were taken from Figures 14-7 and 14-9 for the processing plant having an estimated cost of $35,000,000. For each case with an interest rate of 7 percent, new calculations were made and for a ten year time period the net changed by $0.80; for a twenty year time period, the net changed by $1.10. For a resource recovery system which produces methanol, these nets changed by $1.40 and $1.75 as shown by Figure 14-14. Therefore, decreasing the interest rate does have an impact on the economics of a resource recovery system but for the two considered in this study it is much less of an impact than transportation costs, etc.

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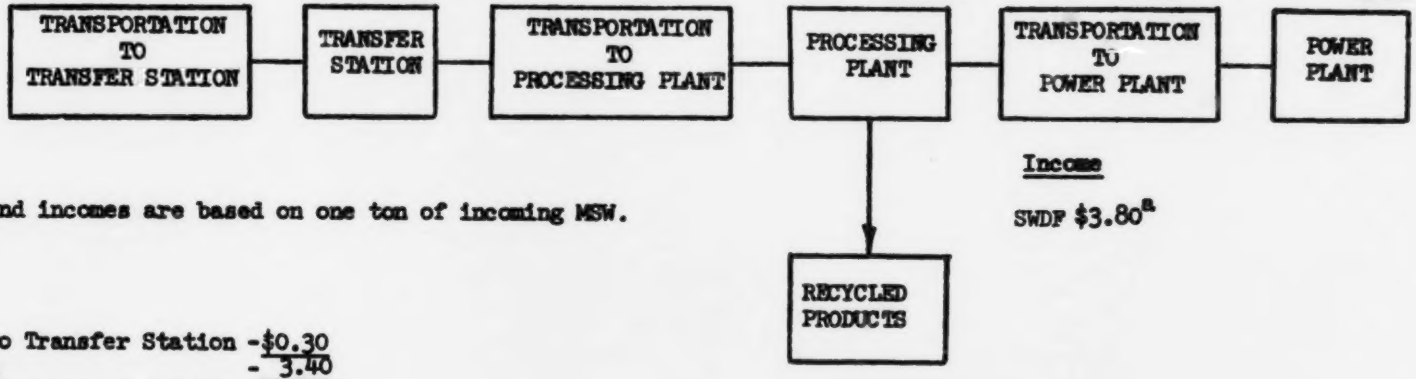
FIGURE 14-1

Time Period : 10 years
Process Plant Cost : $54,000,000 - (2,800 TPD, 5 days/week - 14,000 TPW - 728,000 TPY)

Power Plant Modification: $25,500,000 - (2,000 tons storage)

	Transportation to Transfer Station	Transfer Station	Transportation to Processing Plant	Processing Plant	Transportation to Power Plant	Power Plant
Cap. Costs	$0.10	$2.80	$0.70	$11.30	$0.20	$5.30
Econ. Disp.						0.40
O&M	0.20	0.60	2.00	5.20	0.70	0.90
Landf.				0.30		0.10
Total	$0.30	$3.40	$2.70	$16.80	$0.90	$6.70


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.80[a]

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation to Transfer Station	-$0.30	
Transfer Station	- 3.40	
Transportation to Processing Plant	- 2.70	
Processing Plant	-16.80	
Transportation to Power Plant	- 0.90	
Power Plant	- 6.70	
Total Costs		-$30.80

Income

Sale of Recycled Products	$9.90	
Sale of SWDF	3.80[a]	
		$13.70
NET		-$17.10

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

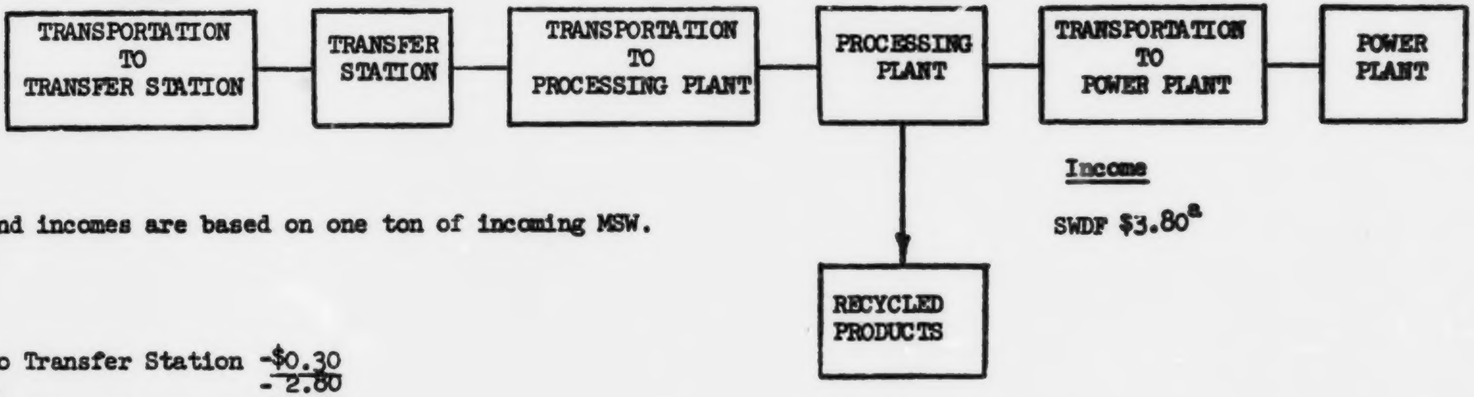
[b] Assumes that aluminum and glass products can be produced to meet specifications.

FIGURE 14-2

Time Period : 15 years
Process Plant Cost : $54,000,000 - (2,800 TPD, 5 days/week - 14,000 TPW - 728,000 TPY)

Power Plant Modification: $25,500,000 - (2,000 tons storage)

TRANSPORTATION TO TRANSFER STATION	TRANSFER STATION	TRANSPORTATION TO PROCESSING PLANT	PROCESSING PLANT	TRANSPORTATION TO POWER PLANT	POWER PLANT
Cap. Costs $0.10	Cap. Costs $2.20	Cap. Costs $0.70	Cap. Costs $ 8.90	Cap. Costs $0.20	Cap. Costs $4.20
O&M 0.20	O&M 0.60	O&M 2.00	O&M 5.20	O&M 0.70	Econ. Disp. 0.50
Total $0.30	Total $2.80	Total $2.70	Landf. 0.30	Total $0.90	O&M 1.00
			Total $14.40		Landf. 0.10
					Total $5.80


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.80[a]

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation to Transfer Station	-$0.30	
Transfer Station	- 2.80	
Transportation to Processing Plant	- 2.70	
Processing Plant	-14.40	
Transportation to Power Plant	- 0.90	
Power Plant	- 5.80	
Total Costs		-$26.90

Income

Sale of Recycled Products	$9.90	
Sale of SWDF	3.80[a]	
		$13.70
NET		-$13.20

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

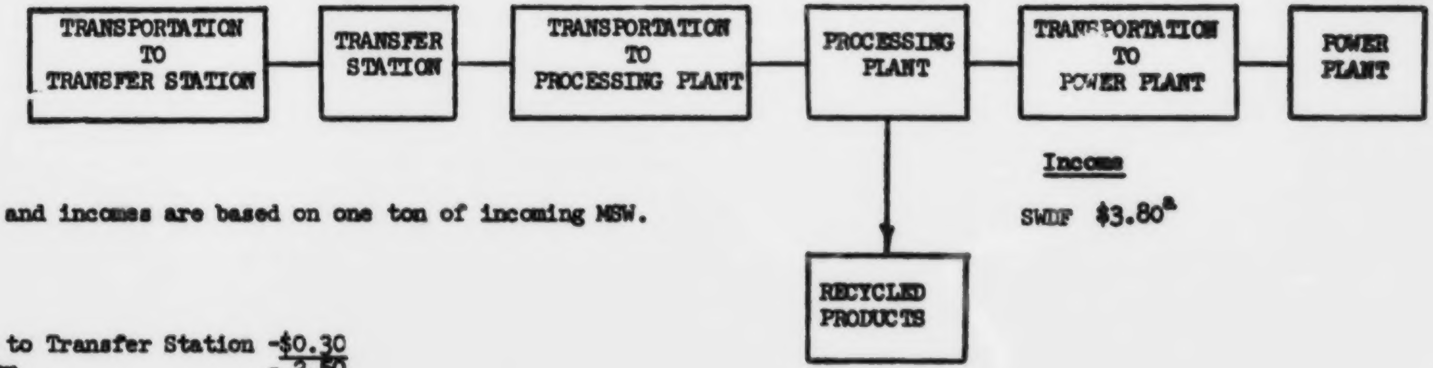
[b] Assumes that aluminum and glass products can be produced to meet specifications.

FIGURE 14-3

Time Period : 20 years
Process Plant Cost : $54,000,000 - (2,800 TPD, 5 days/week - 14,000 TPW - 728,000 TPY)

Power Plant Modification: $25,500,000 - (2,000 tons storage)

	TRANSPORTATION TO TRANSFER STATION	TRANSFER STATION	TRANSPORTATION TO PROCESSING PLANT	PROCESSING PLANT	TRANSPORTATION TO POWER PLANT	POWER PLANT
Cap. Costs	$0.10	$1.90	$0.70	$ 7.80	$0.20	$3.70
Econ. Disp.						0.50
O&M	0.20	0.60	2.00	5.20	0.70	1.10
Landf.				0.30		0.10
Total	$0.30	$2.50	$2.70	$13.30	$0.90	$5.40


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.80[a]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

Costs

Transportation to Transfer Station	-$0.30	
Transfer Station	- 2.50	
Transportation to Processing Plant	- 2.70	
Processing Plant	-13.30	
Transportation to Power Plant	- 0.90	
Power Plant	- 5.40	
Total Costs		-$25.10

Income

Sale of Recycled Products	$9.90	
Sale of SWDF	3.80[a]	
		$13.70
NET		-$11.40

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

[b] Assumes that aluminum and glass products can be produced to meet specifications.

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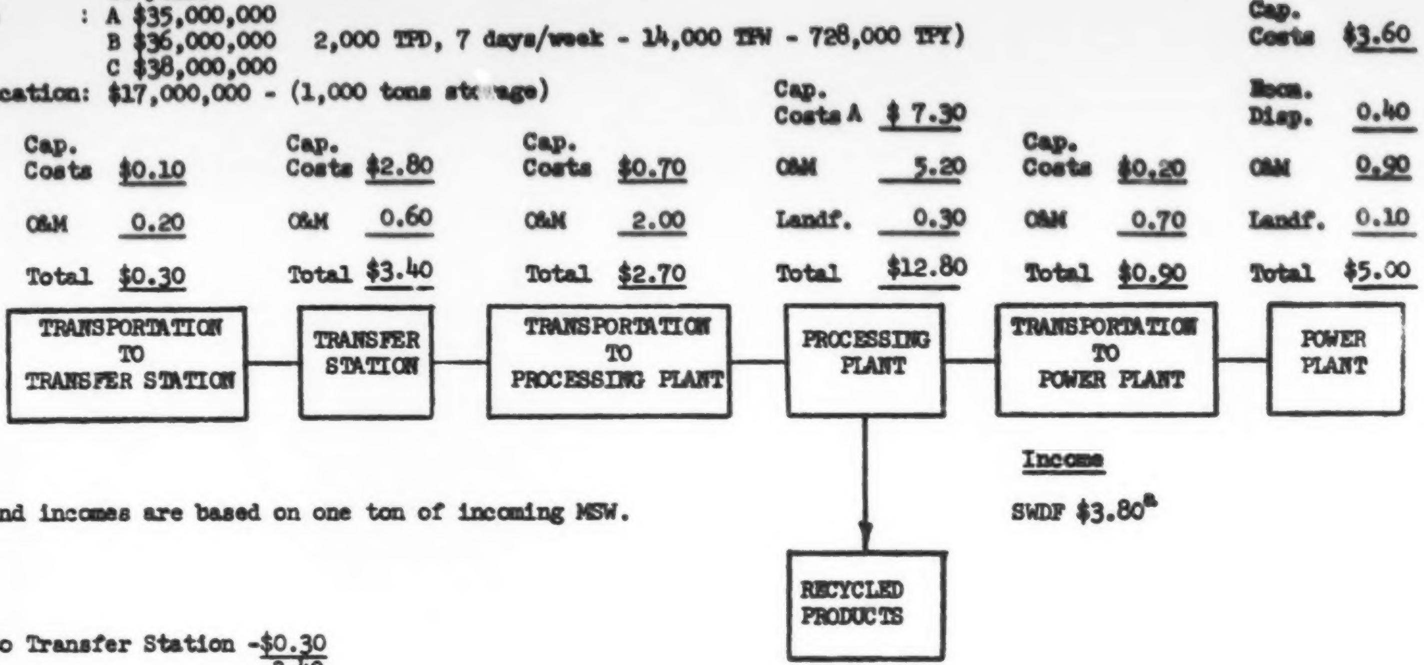
FIGURE 14-4

Time Period : 10 years
Process Plant Cost : A $35,000,000
B $36,000,000 2,000 TPD, 7 days/week - 14,000 TPW - 728,000 TPY)
C $38,000,000
Power Plant Modification: $17,000,000 - (1,000 tons storage)


Cap. Costs $0.10
O&M 0.20
Total $0.30
TRANSPORTATION TO TRANSFER STATION
Cap. Costs $2.80
O&M 0.60
Total $3.40
TRANSFER STATION
Cap. Costs $0.70
O&M 2.00
Total $2.70
TRANSPORTATION TO PROCESSING PLANT
Cap. Costs A $ 7.30
O&M 5.20
Landf. 0.30
Total $12.80
PROCESSING PLANT
Cap. Costs $0.20
O&M 0.70
Total $0.90
TRANSPORTATION TO POWER PLANT
Cap. Costs $3.60
Econ. Disp. 0.40
O&M 0.90
Landf. 0.10
Total $5.00
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.80[a]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation to Transfer Station	-$0.30	
Transfer Station	- 3.40	
Transportation to Processing Plant	- 2.70	
Processing Plant	-12.80	
Transportation to Power Plant	- 0.90	
Power Plant	- 5.00	
Total Costs		-$25.10

Income

Ferrous	$4.50	
Glass & Metals	1.00[b]	
Aluminum	$4.40[b]	

Income

Sale of Recycled Products	$9.90	
Sale of SWDF	3.80[a]	
		$13.70

	A	B	C
NET	-$11.40	-$11.60	-$12.10

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

[b] Assumes that aluminum and glass products can be produced to meet specifications.

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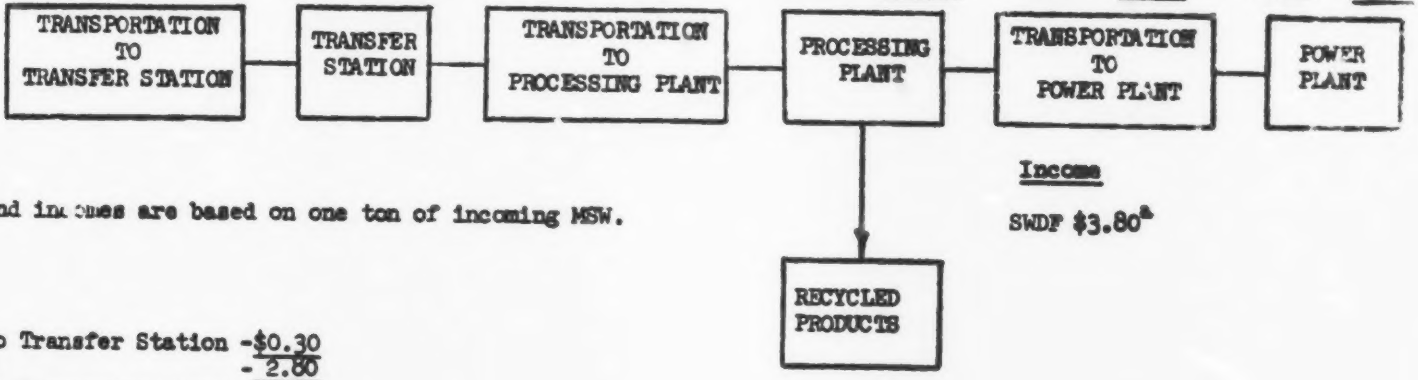
FIGURE 14-5

Time Period : 15 years
Process Plant Cost : A $35,000,000
B $36,000,000 (2,000 TPD, 7 days/week - 14,000 TPW - 728,000 TPY)
C $38,000,000
Power Plant Modification: $17,000,000 - (1,000 tons storage)

TRANSPORTATION TO TRANSFER STATION		TRANSFER STATION		TRANSPORTATION TO PROCESSING PLANT		PROCESSING PLANT		TRANSPORTATION TO POWER PLANT		POWER PLANT	
						Cap. Costs A	$ 5.80			Cap. Costs	$2.8
Cap. Costs	$0.10	Cap. Costs	$2.20	Cap. Costs	$0.70	O&M	5.20	Cap. Costs	$0.20	Resc Disp	0.
O&M	0.20	O&M	0.60	O&M	2.00	Landf.	0.30	O&M	0.70	O&M	1.
										Landf.	0.1
Total	$0.30	Total	$2.80	Total	$2.70	Total A	$11.30	Total	$0.90	Total	$4.4


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.80[a]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation to Transfer Station		-$0.30
Transfer Station		- 2.80
Transportation to Processing Plant		- 2.70
Processing Plant	A	-11.30
Transportation to Power Plant		- 0.90
Power Plant		- 4.40
Total Costs	A	-$22.40

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

Income

Sale of Recycled Products	$9.90
Sale of SWDF	3.80[a]
	$13.70

[illegible]

A	B	C
-$ 8.20	-$8.90	-$9.20

Notes:

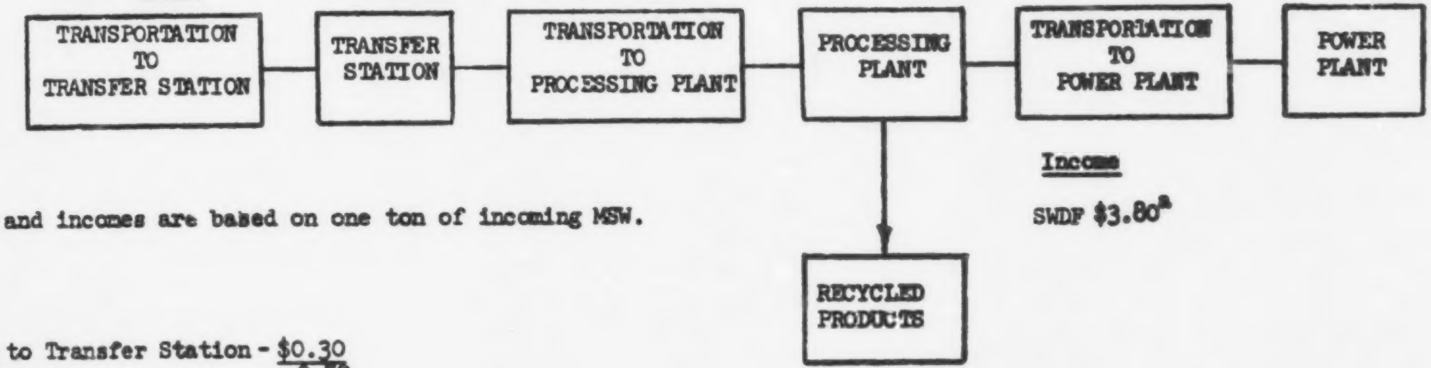
[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

[b] Assumes that aluminum and glass products can be produced to meet specifications.

FIGURE 14-6

Time Period : 20 years
Process Plant Cost : A $35,000,000
B $36,000,000 (2,000 TPD, 7 days/week - 14,000 TPW - 728,000 TPY)
C $38,000,000
Power Plant Modification: $17,000,000 - (1,000 tons storage)

	TRANSPORTATION TO TRANSFER STATION	TRANSFER STATION	TRANSPORTATION TO PROCESSING PLANT	PROCESSING PLANT	TRANSPORTATION TO POWER PLANT	POWER PLANT
Cap. Costs	$0.10	$1.90	$0.70	A $ 5.10	$0.20	$2.50
Econ. Disp.						0.50
O&M	0.20	0.60	2.00	5.20	0.70	1.10
Landf.				0.30		0.10
Total	$0.30	$2.50	$2.70	$10.60	$0.90	$4.20


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.80[a]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

Costs

Transportation to Transfer Station	-	$0.30
Transfer Station	-	2.50
Transportation to Processing Plant	-	2.70
Processing Plant	A -	10.60
Transportation to Power Plant	-	0.90
Power Plant	-	4.20
Total Costs		A -$21.20

Income

Sale of Recycled Products	$9.90
Sale of SWDF	3.80[a]
	$13.70

	A	B	C
NET	-$ 7.50	-$7.60	-$7.90

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

[b] Assumes that aluminum and glass products can be produced to meet specifications.

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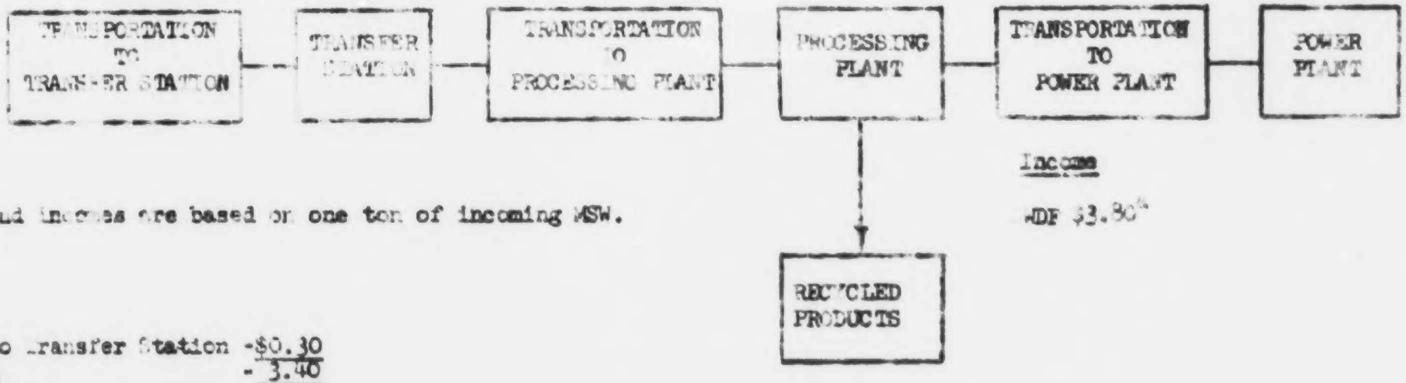
FIGURE 14-7

Time Period	10 years
Process Plant	A $35,000,000 B $36,000,000 (2,000 TPD, 7 days/week - 14,000 TPW - 728,000 TPY) C $38,000,000
Power Plant Modification	$14,000,000 - (Minimum storage)

Transportation to Transfer Station		Transfer Station		Transportation to Processing Plant		Processing Plant		Transportation to Power Plant		Power Plant	
										Cap. Costs	$2.90
						Cap. Costs A	$ 7.30			Econ. Disp.	0.40
Cap. Costs	$0.10	Cap. Costs	$2.80	Cap. Costs	$0.70	O&M	5.20	Cap. Costs	$0.20	O&M	0.90
O&M	0.20	O&M	0.60	O&M	2.00	Landf.	0.30	O&M	0.70	Landf.	0.10
Total	$0.30	Total	$3.40	Total	$2.70	Total A	$12.80	Total	$0.90	Total	$4.30


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

RDF $3.30[a]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

Costs

Transportation to Transfer Station		-$0.30
Transfer Station		- 3.40
Transportation to Processing Plant		- 2.70
Processing Plant	A	-12.80
Transportation to Power Plant		- 0.90
Power Plant+		- 4.30
Total Costs		A -$24.40

Income

Sale of Recycled Products	$9.90
Sale of RDF	3.30[a]
	$13.20

	A	B	C
NET	-$10.[illegible]	-$10.90	-$11.40

Notes:

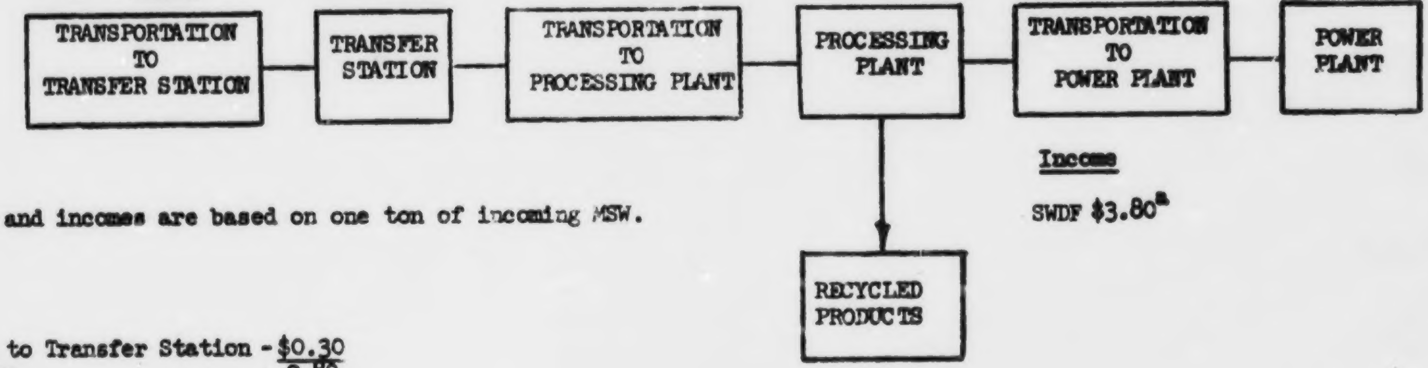
[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

[b] Assumes that aluminum and glass products can be produced to meet specifications.

FIGURE 14-8

Time Period : 15 years
Process Plant Cost : A $35,000,000
B $36,000,000 (2,000 TPD, 7 days/week - 14,000 TPW - 728,000 TPY)
C $38,000,000
Power Plant Modification: $14,000,000 -(Minimum storage)

Transportation to Transfer Station		Transfer Station		Transportation to Processing Plant		Processing Plant		Transportation to Power Plant		Power Plant	
Cap. Costs	$0.10	Cap. Costs	$2.20	Cap. Costs	$0.70	Cap. Costs A	$ 5.80	Cap. Costs	$0.20	Cap. Costs	$2.30
O&M	0.20	O&M	0.60	O&M	2.00	O&M	5.20	O&M	0.70	Econ. Disp.	0.50
Total	$0.30	Total	$2.80	Total	$2.70	Landf.	0.30	Total	$0.90	O&M	1.00
						Total A	$11.30			Landf.	0.10
										Total	$3.90


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.80[a]

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation to Transfer Station		-$0.30
Transfer Station		- 2.80
Transportation to Processing Plant		- 2.70
Processing Plant	A	-11.30
Transportation to Power Plant		- 0.90
Power Plant		- 3.90
Total Costs		A -$21.90

Income

Sale of Recycled Products	$9.90
Sale of SWDF	3.80[a]
	$13.70

	A	B	C
NET	-$ 8.20	-$8.40	-$8.70

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

[b] Assumes that aluminum and glass products can be produced to meet specifications.

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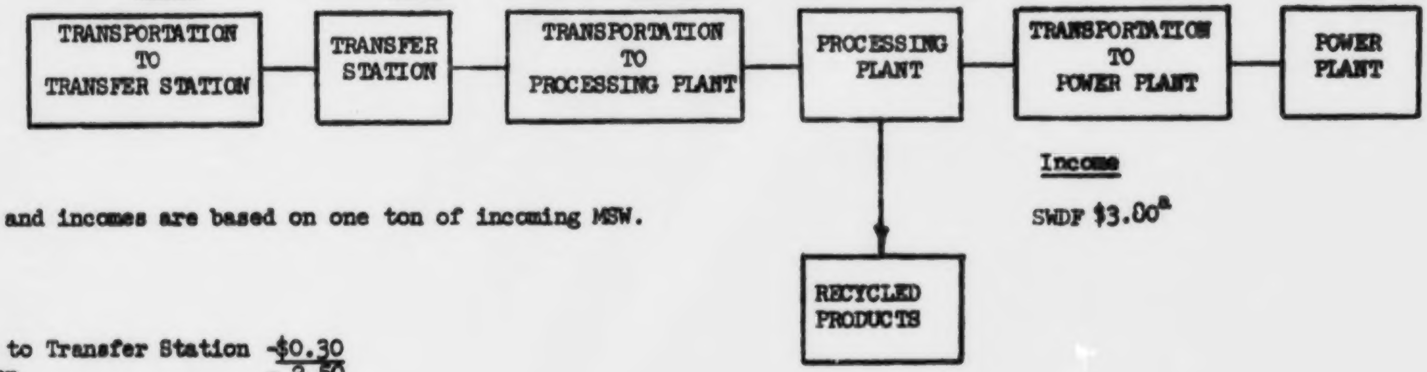
FIGURE 14-9

Time Period : 20 years
Process Plant Cost : A $35,000,000
B $36,000,000
C $38,000,000

(2,000 TPD, 7 days/week - 14,000 TPW - 728,000 TPY)

Power Plant Modification:

Transportation to Transfer Station	Transfer Station	Transportation to Processing Plant	Processing Plant	Transportation to Power Plant	Power Plant
Cap. Costs $0.10	Cap. Costs $1.90	Cap. Costs $0.70	Cap. Costs A $ 5.10	Cap. Costs $0.20	Cap. Costs $2.00
O&M 0.20	O&M 0.60	O&M 2.00	O&M 5.20	O&M 0.70	Econ. Disp. 0.50
			Landf. 0.30		O&M 1.10
					Landf. 0.10
Total $0.30	Total $2.50	Total $2.70	Total A $10.60	Total $0.90	Total $3.70


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income

SWDF $3.00[a]

Income

Ferrous	$4.50
Glass & Metals	1.00[b]
Aluminum	$4.40[b]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation to Transfer Station	-$0.30	
Transfer Station	- 2.50	
Transportation to Processing Plant	- 2.70	
Processing Plant	-10.60	
Transportation to Power Plant	- 0.90	
Power Plant	- 3.70	
Total Costs		A -$20.70

Income

Sale of Recycled Products	$9.90
Sale of SWDF	3.80[a]
	$13.70

	A	B	C
NET	-$ 7.00	-$7.10	-$7.40

Notes:

[a] Based on coal costs for current deliveries. Due to TVA's efforts to increase ESP efficiency by switching to different coal, this value could increase to about $5.30 per ton of MSW in the future.

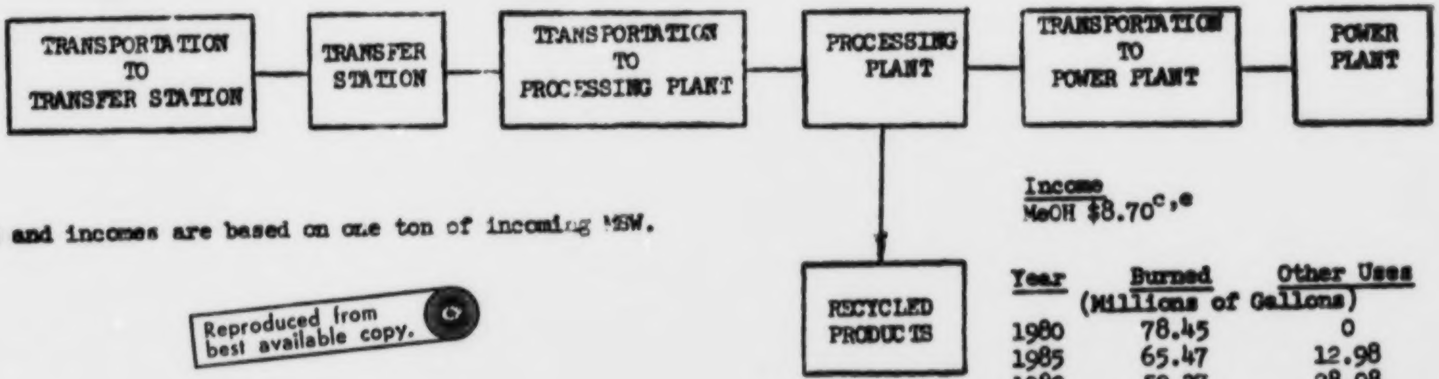
[b] Assumes that aluminum and glass products can be produced to meet specifications.

FIGURE 14-10

Time Period : 10 years
Processing Plant Cost: $56,000,000 (3,850 TPD, 7 days/week - 27,000 TPW - 1,404,000 TPY)

Gasification & Methanation Plant Cost Including Pumping Station To Methanation Plant = $105,000,000

	Transportation to Transfer Station	Transfer Station	Transportation to Processing Plant	Processing Plant	Transportation to Power Plant	Power Plant
Cap. Costs	$0.60	$2.60	$1.10	$17.50	$0.10	$1.10[b]
Econ. Disp.						______
O&M	1.00	0.50	2.40	8.90	0.30	______
Landf.				______		______
Total	$1.60[d]	$3.10[d]	$3.50[d]	$26.40[a]	$0.40	$1.10[b]


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income
MeOH $8.70[c,e]

Year	Burned	Other Uses
	(Millions of Gallons)	
1980	78.45	0
1985	65.47	12.98
1989	50.37	28.08

Income

Ferrous	$4.50
Glass & Metals	1.00[f]
Aluminum	4.40[f]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation	-$ 8.20	
Processing Plant	- 26.40	
Transportation to Power Plant	- 0.40	
Power Plant	- 1.10	
Total Costs		-$36.10

Income

Sale of Recycled Products	$ 9.[illegible]	
Sale of [illegible]	[illegible]	
Total Income		[illegible]

Notes:

Includes [illegible] .70/ton O&M for preprocessing MSW

Includes cost of modifying gas-turbines & fuel storage facilities
Based on projected average cost of No. 2 oil in 1977.
[illegible] transportation costs estimated by scaling up solid fuel [illegible] costs.
[illegible] methanol produced can be used in TVA turbines.
[illegible] aluminum and glass products can be produced to

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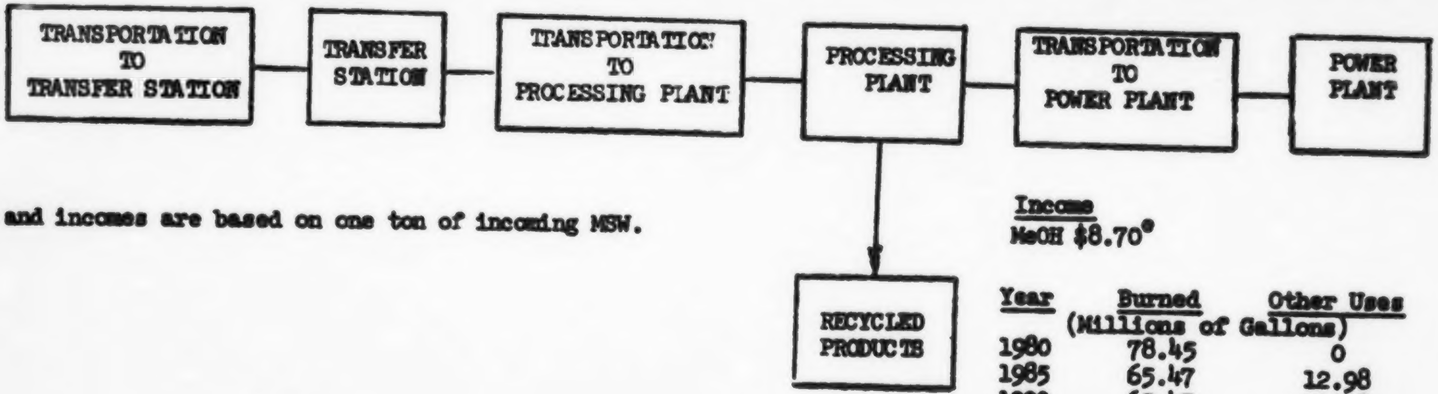
FIGURE 14-11

Life Period : 15 years
Processing Plant Cost: $56,000,000 (3,850 TPD, 7 days/week - 27,000 TPW - 1,404,000 TPY)

Gasification & Methanation Plant Cost Including Pumping Station To Methanation Plant = $105,000,000

	Transportation to Transfer Station	Transfer Station	Transportation to Processing Plant	Processing Plant	Transportation to Power Plant	Power Plant
Cap. Costs	$0.60	$2.00	$1.10	$13.80	$0.10	$0.90[b]
Econ. Disp.						
O&M	1.00	0.50	2.40	8.90	0.30	
Landf.						
Total	$1.60[d]	$2.50[d]	$3.50[d]	$22.70	$0.40	$0.90[b]


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

NOTE: All costs and incomes are based on one ton of incoming MSW.

Income
MeOH $8.70[e]

Year	Burned (Millions of Gallons)	Other Uses
1980	78.45	0
1985	65.47	12.98
1990	65.47	12.98
1994	70.54	7.91

Income

Ferrous	$4.50
Glass & Metals	1.00[f]
Aluminum	4.40[f]

Costs

Transportation	-$ 7.60	
Processing Plant	- 22.70	
Transportation to Power Plant	- 0.40	
Power Plant	- 0.90	
Total Costs		-$31.60

Income

Sale of Recycled Products	$ 9.90	
Sale of SWDF	9.70	
Total Income		$19.60
NET		-$12.00

Notes:

[a] Includes $1.70 /ton O&M for preprocessing MSW

[b] Includes cost of modifying gas-turbines & fuel storage facilities

[c] Based on projected average cost of No. 2 oil in 1977.

[d] MSW transportation costs estimated by scaling up solid fuel transportation costs.

[e] Assumes all methanol produced can be used in TVA turbines.

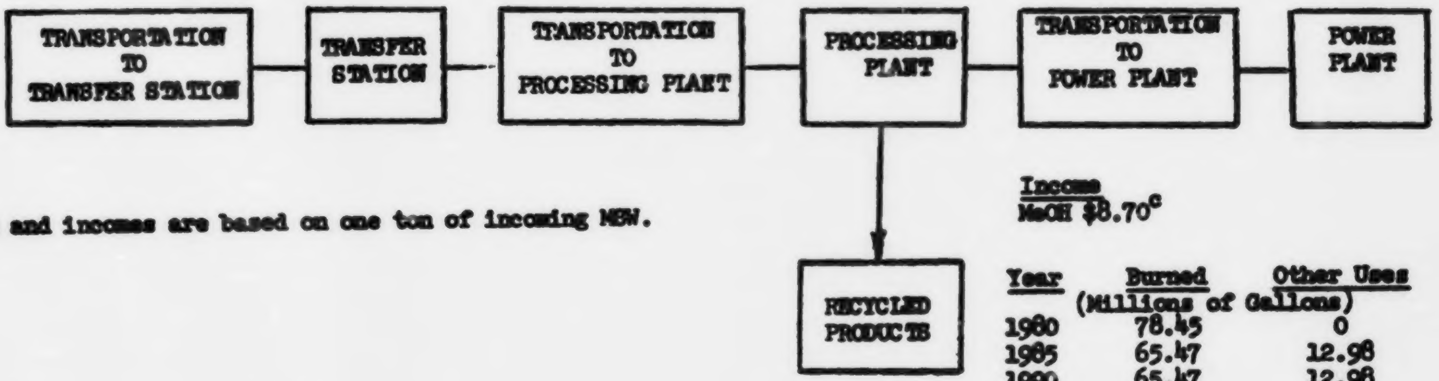
[f] Assumes that aluminum and glass products can be produced to specification.

FIGURE 14-12

Time Period : 20 years
Processing Plant Cost: $56,000,000 (3,850 TPD, 7 days/week - 27,000 TPW - 1,404,000 TPY)

Gasification & Methanation Plant Cost Including Pumping Station To Methanation Plant = $105,000,000

Transportation to Transfer Station	Transfer Station	Transportation to Processing Plant	Processing Plant	Transportation to Power Plant	Power Plant
Cap. Costs $0.60	Cap. Costs $1.80	Cap. Costs $1.10	Cap. Costs $12.10	Cap. Costs $0.10	Cap. Costs $0.80[b]
					Econ. Disp. ____
O&M 1.00	O&M 0.50	O&M 2.40	O&M ____	O&M 0.30	O&M ____
			Landf. 8.90		Landf. ____
Total $1.60[d]	Total $2.30[d]	Total $3.50[d]	Total $21.00	Total $0.40	Total $0.80[b]


TRANSPORTATION TO TRANSFER STATION
TRANSFER STATION
TRANSPORTATION TO PROCESSING PLANT
PROCESSING PLANT
TRANSPORTATION TO POWER PLANT
POWER PLANT
RECYCLED PRODUCTS

Income
MeOH $8.70[c]

Year	Burned	Other Uses
	(Millions of Gallons)	
1980	78.45	0
1985	65.47	12.98
1990	65.47	12.98
1995	55.44	23.01
1999	30.26	48.20

Income

Ferrous	$4.50
Glass & Metals	1.00[f]
Aluminum	4.40[f]

NOTE: All costs and incomes are based on one ton of incoming MSW.

Costs

Transportation	-$ 7.40	
Processing Plant	- 21.00	
Transportation to Power Plant	- 0.40	
Power Plant	- 0.80	
Total Costs		-$29.60

Income

Sale of Recycled Products	$ 9.90	
Sale of SWDF	8.70	
Total Income		$18.60
NET		-$11.00

Notes:

[a] Includes 1.70/ton O&M for preprocessing MSW

[b] Includes cost of modifying gas-turbines & fuel storage facilities

[c] Based on projected average cost of No. 2 oil in 1977.

[d] MSW transportation costs estimated by scaling up solid fuel transportation costs.

[e] Assumes all methanol produced can be used in TVA turbines.

[f] Assumes that aluminum and glass products can be produced to specification.

FIGURE 14-13

COST SUMMARY - SWDF BURNED IN MODIFIED BOILER

COST OF PLANT: $35,000,000

PLANT CAPACITY: 2000 TPD, 7 DAYS/WK., 14,000 TPW

POWER PLANT MOD.: 14,000,000 (MINIMUM STORAGE)

TIME PERIOD:	10 YR		20 YR	
INTEREST RATE:	8-1/2	7	8-1/2	7
TOTAL COSTS				
TRANSPORTATION	3.90	3.90	3.90	3.80
TRANSFER STATION	3.40	3.20	2.50	2.30
PROCESSING PLANT	12.80	12.40	10.60	10.00
POWER PLANT	4.30	4.10	3.70	3.50
TOTAL INCOME				
RECYCLED PRODUCTS	9.90	9.90	9.90	9.90
SALE OF RDF	3.80	3.80	3.80	3.80
NET	-10.70	-9.90	-7.00	-5.90

FIGURE 14-14

COST SUMMARY-WASTE GASIFICATION AND METHANOL PRODUCTION

COST OF PLANT: $161,000,000

PLANT CAPACITY: 3850 TPD, 7 Days/wk., 27,000 TPW

Time Period:	10 YR		20 YR	
Interest Rate :	8-½	7	8-½	7
Total Costs				
Transportation	5.50	5.40	5.50	5.30
Transfer Station	3.10	2.90	2.30	2.10
Plant	26.40	25.30	21.00	19.75
Power Plant	1.10	1.10	0.80	0.70
Total Income				
Recycled Products	9.90	9.90	9.90	9.90
Sale of Methanol	8.70	8.70	8.70	8.70
Net	-17.50	-16.10	-11.00	-9.25

SECTION XV

FINDINGS OF STUDY

1. Cost estimates and revenue estimates are not transferable to other study areas; the former because of differences in waste quantities, transportation costs, variations in the cost of facilities to process and utilize the fuel, and differences in construction costs; the latter because of differences in waste characteristics from place to place, the availability of suitable markets, and the value of fuel to different users. However, the methods used to determine these estimates are transferable.

2. It is essential to have an accurate analysis of the location, quantity, and character of the waste supply.

3. A well-designed waste sampling program is essential to resource recovery planning since substantial variations in the character of waste exist from place to place.

4. In higher income areas, ferrous metal content remains relatively stable year round; however, lower income areas show significant differences between summer and winter samples. Nonferrous metals correlate to both income and season.

5. If beverage cans represent 22 to 26 percent of the ferrous metal content in the waste stream and 28 to 32 percent of the nonferrous metal content, then accordingly, complete removal of the beverage cans from the waste stream would reduce potential income to a resource recovery project by about $2.50 per ton of waste processed over the life of the project. This represents about 25 percent of the revenues possible from the sales of recovered products. This assumes that the processing plant was built before mandatory beverage container deposit legislation is enacted, and that the aluminum product can be recovered to meet specifications.

6. Collection and transportation costs are a major cost element in any regional resource recovery system operating in a region with dispersed population and with power plants remotely located from urban areas. Approximately 1/5 to 1/3 of the

cost of the alternatives considered in the TVA study can be attributed to transportation. If significant quantities of waste must be transported more than 50 miles to a processing center, rail haul should be considered. The most economical method of rail hauling is a rotary-discharge hopper car. Storage requirements in the system should take advantage of storage available in transportation systems.

7. Based on transportation economics, the processing plant should be located in the jurisdiction nearest the fuel consumption facility which has the largest percentage of waste available.

8. In general, the minimum waste supply needed to justify a complete resource recovery waste processing plant would be 500 tons per day. The optimum waste supply would be in the range of 2,000 to 3,000 tons per day.

9. A 500 to 1,000 tons-per-day waste processing plant should consider the use of a single line of equipment to achieve maximum utilization of capital investment. A 3,000 tons-per-day or greater waste processing plant does not necessarily produce economics of scale and can present ligistics problems. For economic reasons, the processing plant should operate 16 hours per day, 7 days per week. However, without redundant systems, this schedule may not allow sufficient time to perform the required maintenance. A waste processing facility should allow for minimum storage of one day's supply of waste.

10. Screening of raw waste prior to shredding by using a rotating trommel can produce processing benefits, including extraction of most glass and a majority of the metal cans.

11. Glass and aluminum recovery should be considered on an add-on basis.

12. On the basis of aluminum and glass content in the region under study and the prices bid for such products, discrete aluminum separation and froth floated glass removal appear to be economically justifiable. However, the technology as of yet has not been demonstrated at commercial scale.

13. Maximum revenue can be obtained from waste processing facilities that concentrate large quantities of marketable products at one location.

14. Maximum income from ferrous metals can normally be obtained from detinning companies. A minimum of at least 30,000 tons per year of ferrous product will be required to entice a detinning company to locate a plant in the vicinity of the waste processing plant.

15. Aluminum scrap can be classified in two categories, all-aluminum cans and aluminum alloys. Aluminum recovery can be accomplished by using "aluminum magnet" or "heavy media separation" technology. Based on vendor's estimates, the cost of extracting aluminum from an aluminum rich stream will range from $50 to $100 per ton of aluminum recovered. This range depends on the percentage of aluminum in the incoming solid waste.

16. Other nonferrous metals may be stockpiled and marketed to companies utilizing heavy-media separation techniques on a spot-sale basis; however, the crude product shipped to the processing company must have a minimum metals concentration of 25 percent.

17. Glass can be marketed with a quality guarantee in the form of a mixed-color glass cullet for approximately $15 per ton f.o.b. the glass company. A froth-flotation module is estimated to cost approximately $5 to $10 per ton of glass produced; however, this technology has not been demonstrated at commercial scale. Shipment of the recovered glass product can be economical if the term "glass cullet" is not used for rail haul quotations.

18. The newest electrostatic precipitators (ESP) either installed, under construction, or planned at the TVA fossil-fired steam plants considered in this study, when performing at their design efficiency, may control emissions sufficiently at some plants to prevent violations of particulate emission standards when the boiler is fired with a 10-percent Btu input from solid waste-derived fule (SWDF). However, it has been reported that ESP efficiency decreases 1 to 3 percent when burning coal combined with SWDF; and therefore, violations of these standards may occur at all these plants. Actual validation of the adequacy of the ESP's performance in meeting emission standards when burning coal combined with SWDF will be required even though ESP's at some plants will have a safety margin that might handle increases in particulate inlet loading. Ambient particulate standards are not expected to be exceeded when point source particulate emission standards are met.

19. Ground and surface waters at and near the steam plants are not expected to be adversely affected by firing with SWDF when a quality fuel sized for maximum possible combustion and essentially free of noncombustible material is provided.

20. To maximize revenue for SWDF, power plant modification costs should be held to a minimum. This can be done by dispatching fuel to a power plant as needed, thereby eliminating the need for large live-bottom storage bins at the power plant. Minimum storage requirements (probably [illegible] to [illegible] tons) are dependent upon the amount required to allow continuous feeding

of the SWDF to the boiler or boilers.

21. There is not sufficient information available regarding the use of SWDF in large power boilers to conclude its effects on boiler corrosion, electrostatic precipitator performance, bottom ash and ash pond contamination, and boiler efficiency. These and other technical questions, such as SWDF firing rates and boiler loads at which these rates can be used, need to be answered.

22. Both fuel oil and natural gas are in short supply. The syngas produced from solid waste could become a substitute for oil (in the case of methanol) and for natural gas (in the case of ammonia production).

23. TVA may be able to consume, through its power production and fertilizer manufacturing activities, either, or both, MeOH and ammonia which would eliminate the need for any external sales of these products.

24. Syngas from solid waste and products synthesized from that syngas are expensive in terms of today's prices and have not yet been produced on a commercial scale. Methanol and ammonia produced as a result of coal gasification should be considerably cheaper than the fuel produced from municipal solid waste, although the capital required is considerably greater.